

## REMARKS/ARGUMENTS

### Rejection under 35 U.S.C. §103(a)

Claims 26-50 are still rejected under 35 U.S.C. §103(a) as being unpatentable over Harrison et al. (6,358,892) or Harrison et al. (5,853,434), which rejection is respectfully traversed on the grounds asserted below.

Applicants arguments filed 2 July 2004 have been fully considered but they are not persuasive. As set forth in the previous office action, Harrison et al. ["Harrison"] references disclose compositions comprising polyalkylene polysuccinimides, and post-treated derivatives thereof, which act as dispersants in lubricating oils and as deposit inhibitors in hydrocarbon fuels. The polyalkylene compositions can be prepared by reacting a mixture of an alkenyl or alkylsuccinic acid derivative, an unsaturated acidic reagent copolymer, and a polyamine under reactive conditions. See formula (1) set forth in column 6, lines 15-42, of ('892) and column 4, lines 8-30 of ('434). The alkenyl or alkyl substituent R, of the alkenyl or alkylsuccinic acid derivative has a MN of from 1800 to 3000. The unsaturated acidic reagent copolymer has an average degree of polymerization, x, of from 2 to 20, and is a copolymer of an unsaturated acidic reagent and an olefin wherein R' is an alkyl having an average of from 12 to 28 carbon atoms. The polyamine has at least three nitrogen atoms and has from 4 to 20 carbon atoms. The examiner is of the position that the polyalkylene polysuccinimides set forth in the Harrison references appear to meet the limitations of the polymers in applicants' independent claim 26 and the process for preparing the polymers in independent claims 35 and 37. The only differences appear to be substituent R<sub>1</sub> which is methyl in applicants' claims and hydrogen in Harrison. The examiner is of the position that this is an obvious variance which is not expected to effect the properties of the polysuccinimides compound. Harrison teaches that the polysuccinimides compound may be post-treated by reaction with a cyclic carbonate, a boron compound such as boric acid, and other compounds inorganic phosphorous acids. See column 13, line 40 to column 16, lines 35 of ('892). Thus, the examiner is of the position that the Harrison references meet the limitations of the above rejected claims.

Applicants argue that the important difference between the Harrison references and the present invention lies in the

composition of the copolymer used to make the polymeric succinimides. Applicants argue that the polymeric succinimides in the Harrison references are made from polyisobutenyl succinic anhydride, a copolymer of an *alpha olefin* and maleic anhydride and an amine, which differs from applicants' polymeric succinimides which are made from polyisobutenyl succinic anhydride, *low molecular weight polyisobutene* and maleic anhydride and an amine. This is not deemed to be persuasive because alpha olefins having 12 to 28 carbon atoms of Harrison is seen to be indistinguishable from polyisobutylene having less than 32 carbon atoms in applicants' invention. Polyisobutylene is an example of an alpha olefin. Indeed, Harrison teaches in column 12, lines 25-28 of ('892) that polyisobutene-co-maleic anhydride resins are an example of maleic anhydride  $\alpha$ -olefin copolymers which may be used to prepare the polymeric succinimides of the patented invention.

#### Amendment to Claims

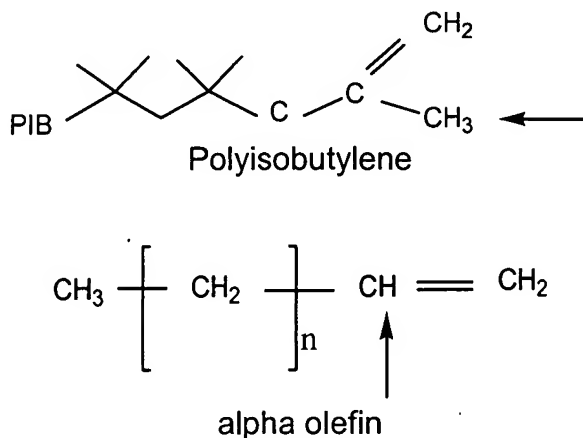
Independent claims 26 and 37 have been amended to conform to the amendment made to independent claims 1, 6, and 14 related to the copolymer used to prepare the polymer of independent claim 26 and the succinimides prepared in independent claim 37.

#### Remarks

The Examiner maintains the position that the polyalkylene polysuccinimides set forth in the Harrison references appear to meet the limitations of the polymers in applicants' claims 26-50.

Applicants' amended independent claims 26 and 37 are unobvious over the Harrison references because the polymer in the amended independent claims 26 and 37 is prepared from PIB/UAR copolymer, an alkenyl acid derivative and an amine. Amended claims 26 and 37 are not obvious over Harrison ('892) because Harrison uses alpha olefin, not polyisobutyl to prepare the polysuccinimide. Alpha olefin and polyisobutyl are very different. A person of

ordinary skill in the art would not think that the two are interchangeable. Although, they both have alpha double bonds, they are very different chemicals, because alpha olefin has only one substitution on the beta carbon while polyisobutyl has two.



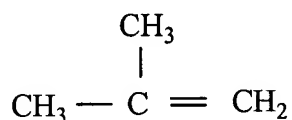
The major difference between polyisobutylene and alpha olefins is that polyisobutylene is di-substituted and alpha olefins are mono-substituted on the second carbon as shown by use of arrows in the structures above.

Alpha olefin in the Harrison reference U.S. Patent No. 6,358,892 is defined as the "monomer corresponding to R<sup>1</sup> in formula (I) plus a vinyl group, i.e., R<sup>1</sup>-CH=CH<sub>2</sub>." See column 11, lines 32-34. Structures of the examples of alpha olefins given in column 11, lines 35-47 in the Harrison reference are given below for comparison with the above structure of polyisobutylene used in amended claims 26 and 37 in the present invention:

- (a) C<sub>8</sub> to C<sub>48</sub> alpha olefin – R-CH=CH<sub>2</sub>, a linear alpha olefin, wherein the R is C<sub>6</sub> to C<sub>46</sub>
- (b) C<sub>8</sub> to C<sub>28</sub> polyalkene – R-CH=CH<sub>2</sub>, a branched polyolefin, wherein the R is C<sub>6</sub> to C<sub>26</sub>

- (c) Ethylene –  $\text{CH}_2=\text{CH}_2$
- (d) Styrene (phenylethylene) –  $\text{C}_6\text{H}_5 - \text{CH}=\text{CH}_2$
- (e) 1,3-butadiene –  $\text{CH}_2=\text{CH}_2 - \text{CH}_2=\text{CH}_2$
- (f)  $\text{C}_{3+}$  vinyl alkyl ether –  $\text{CH}_2\text{CHOR}$ , wherein R is  $\text{C}_{3+}$
- (g)  $\text{C}_{4+}$  vinyl alkanoate –  $\text{CH}_2\text{OCOR}$ , wherein R is  $\text{C}_{4+}$
- (h) Preferred alpha olefins are  $\text{C}_{12}$  to  $\text{C}_{28}$ , and mixtures of olefins, e.g.,  $\text{C}_{14}$ ,  $\text{C}_{16}$  and  $\text{C}_{18}$  are especially desirable.

*Harrison does not include isobutene as an alpha olefin monomer in the examples given above for preparation of the unsaturated acidic reagent copolymer because it is not within the definition of alpha olefin in Harrison. See structure below:*



Applicants also draw the Examiner's attention two sales brochures on alpha olefins in Appendix A. The sales brochures provide various examples of alpha olefins having the generic formula shown above. A person of ordinary skill in the art would understand the examples of alpha olefins in the two brochures as being different from the structure of a polyisobutylene shown above.

Applicants disagree with the Examiner's position because Harrison does not suggest, teach or disclose the use of polyisobutylene for making the unsaturated acidic reagent copolymer, PIB/UAR copolymer, of the present invention. What Harrison teaches is the use of alpha olefins to make the unsaturated acidic



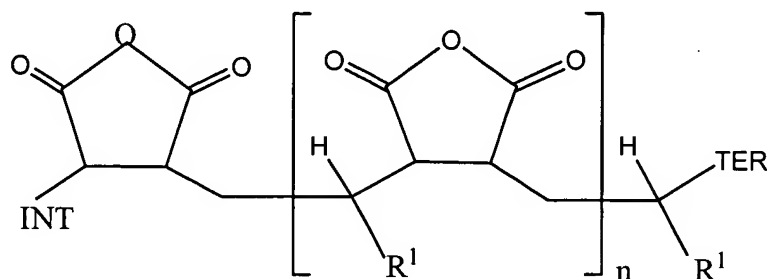
reagent copolymer, Reagent B. See Harrison U.S. Patent No. 6, 358,892, column 11, starting on line 23 and ending column 12, line 41.

Harrison does not suggest, teach or disclose the use of polyisobutylene to make the unsaturated acidic reagent copolymer. Harrison uses alpha olefins to make the unsaturated acidic reagent copolymer. In the Harrison reference it is important to distinguish between the polyolefin used to make the *alkenyl or alkylsuccinic acid derivative – Reactant A* (see col. 10 beginning on line 14 and ending col. 11, line 21) and the alpha olefin used to make the *unsaturated acidic reagent copolymer - Reactant B* (see col. 11, starting on line 23 and ending col. 12, line 41).

Harrison does use polyolefin having an average molecular weight from 1,000 to 5,000 and particularly preferred are polybutenes prepared by polymerization of one or more of 1-butene, 2-butene and isobutene for making the alkenyl or alkylsuccinic acid, but not to make the unsaturated acid reagent copolymer as in the present invention. The unsaturated acidic reagent copolymer in Harrison uses alpha olefins and the unsaturated acid reagent copolymer, the PIB/UAR copolymer, in the present invention uses polyisobutene.

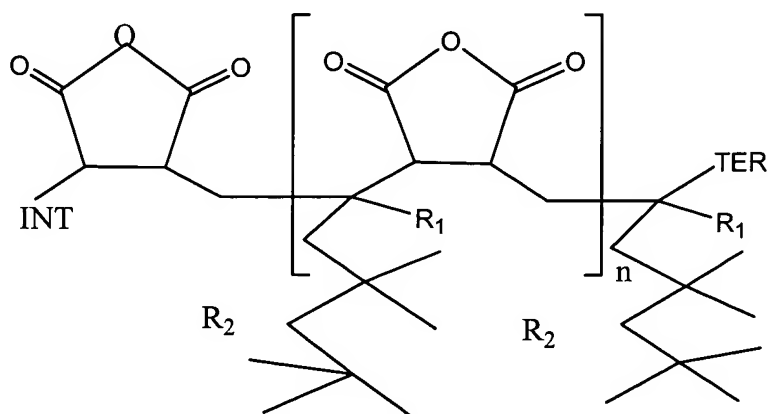
Thus, to say that the disclosure of the use of polyisobutene to make the *alkenyl or alkylsuccinic acid (Reagent A)* in Harrison et al makes the use of the polyisobutene to make the unsaturated acid reagent, PIB/UAR (*which is Reagent B in Harrison et al.*) obvious is like comparing apples and oranges since the alkenyl or alkylsuccinic acid is very different from the unsaturated acidic reagent copolymer. We need to compare the *unsaturated acidic reagent copolymer - Reactant B* in Harrison to the PIB/UAR copolymer in the present invention to determine whether Harrison suggests, teaches or discloses the use of PIB to make the PIB/UAR copolymer of the present invention, and when such a comparison is made, it does not.

This difference between the unsaturated acidic reagent copolymer in the Harrison invention and that in the present invention is observed in comparing the preparation of the two copolymers in the examples given to make the copolymers. In Harrison, Preparation 1 in column 18, lines 21-38, uses a mixture of C<sub>14</sub>, C<sub>16</sub> and C<sub>18</sub> alpha olefins for preparing the copolymer. The copolymer, thus prepared, has the structure given below:



wherein R<sup>1</sup> is a mixture of C<sub>14</sub>, C<sub>16</sub> and C<sub>18</sub> alpha olefins and n is a whole integer between 1 and 3. There is only one R group, R<sup>1</sup>, in Harrison, the fourth bond on the carbon atom is with hydrogen, i.e., the carbon is mono-substituted.

The PIB/UAR copolymer of the present invention is prepared in Example 5 using a low molecular weight PIB and the copolymer has the structure given below:



wherein R<sub>1</sub> is CH<sub>3</sub>, and R<sub>2</sub> is low molecular weight PIB having about 5 carbon atoms to 25 carbon atoms. The carbon atom has two R groups, R<sub>1</sub> and R<sub>2</sub>, and thus, the carbon is di-substituted.

In addition to the difference in the structures of the two copolymers, it was surprisingly found that the copolymer of the present invention was liquid, while the copolymer prepared in Harrison was solid. A further difference found was that the copolymer of the present invention did not need an aromatic solvent as a chain transfer agent to prevent the copolymer becoming very large, while the Harrison copolymer could only be prepared in aromatic solvent to obtain low molecular weight copolymers.

Table 2 on page 44 of the specification of the present invention shows the preparation of the copolymers with and without the use of solvent. It is seen that the molecular weights were comparable for the PIB/UAR copolymers prepared with or without solvent in Examples 1, 2, 5-7, but the alpha olefin copolymer prepared without solvent in Example 4 was very large compared to that prepared with solvent in Example 3.

The above definition of alpha olefins does not include polyisobutene and the above comparison of the R groups in the Harrison reference and the present invention shows that while in Harrison the copolymer has a mono-substituted alpha olefin, the present invention has a di-substituted polyisobutene. Harrison does not suggest, teach or disclose Applicants' present invention, thus, claims 26-50 are non-obvious over Harrison.

The Examiner notes that Harrison teaches in column 12, lines 25-28 of ('892) that poly(isobutene-co-maleic anhydride) resins are an example of maleic anhydride alpha olefin copolymers which may be used to prepare the polymeric succinimides of the patented invention. Applicants draw the Examiner's attention to a brochure for poly(isobutene-co-maleic anhydride) (ISOBAM) in Appendix B. The chemical structure of ISOBAM does not include a polyisobutenyl group. ISOBAM is a polymer which has an isobutene moiety in the repeating monomers of the polymer chain. In other words, a person skilled in the art would not

replace polyisobutyl in the polymer of independent claims 26 and 37 with poly(isobutene-co-maleic anhydride) resins (ISOBAM) for the following reasons:

In the first instance,  $R_1$  and  $R_2$  in ISOBAM are different from the  $R_1$  and  $R_2$  in the copolymer of amended claim 26 and the copolymer of claim 37 of the present invention. In ISOBAM  $R_1$  and  $R_2$  are both methyl. The copolymer of claims 26 has only one methyl group, the other must be polyisobutyl having about 5 carbon atoms to about 25 carbon atoms.

In the second instance, ISOBAM products are water soluble. The PIB/UAR copolymer of amended independent claims 26 and 37 of the present invention is essentially insoluble in water, but soluble in polar solvents.

In the third instance, ISOBAM products are solid, white powders at ambient temperature. The copolymer in amended independent claims 26 and 37 of the present invention is liquid at ambient temperature.

In light of the above, the Examiner is urged to reconsider her obviousness rejection of claims 26-50 based on the Harrison et al references.

Claims 1-25 are still rejected under 35 U.S.C. §103(a) as being unpatentable over Ruhe Jr. et al. (5,175,225), which rejection is respectfully traversed on the grounds asserted below.

Ruhe, Jr. discloses oligomeric copolymers having alternating succinic and polyalkylene groups which may be used as intermediates for dispersants themselves in lubricating oil compositions. Ruhe, Jr. also discloses a process for preparing the oligomeric copolymers. The copolymers are set forth in column 6, lines 45-53, wherein  $W'$  and  $Z'$  are independently selected from -OH, -OH-lower alkyl or taken together are -O- to form a succinic anhydride group, and the R substituents may be hydrogen, lower alkyl groups of 1 to 6 carbon atoms, and higher alkyl groups of at least 30 carbon atoms. The examiner is of the position that the oligomeric copolymer of Ruhe, Jr. meet the limitations of the copolymers of independent claims 1 and 14 when n is 1 and m is 1.

Applicants argue that the major difference between the preparation of the oligomeric copolymer in Ruhe, Jr. and the preparation of the copolymer of the present invention is that in Ruhe, Jr. the copolymers are prepared using high molecular weight olefins as polyisobutenes having an average molecular weight of about 500 to 5,000. In contrast, applicants' argue, the copolymers in the present invention are prepared using low molecular weight polyisobutene having a molecular weight of about 448 or less. This is not deemed to be persuasive of patentability of the claims at issue because there is still an overlap in the claimed invention of a polyisobutylene having less than 32 carbon atoms and Ruhe, jr. which teaches a polyisobutyl having at least 30 carbon atoms for the same component. See column 5, lines 13-14. Although, Ruhe, Jr. prefers a higher carbon atom chain, preferably about 50 carbon atoms, at least 30 carbon atoms is taught as suitable for this component. Thus, the examiner maintains the position that the oligomeric copolymer of Ruhe, Jr. meets the limitations of the copolymers of independent claims 1 and 14 when n is 1 and m is 1.

#### Amendment to the Claims

Applicants have amended independent claims 1, 6 and 14, to include the limitation of claims 2 and 3 into claim 1, i.e., "one of R<sub>1</sub> and R<sub>2</sub> comprise methyl and the other of R<sub>1</sub> and R<sub>2</sub> comprises polyisobutyl having about 5 to about 25 carbon atoms" from claim 2, and "liquid at ambient temperature" from claim 3. Also claims 11, 13, 20, 24 and 25 have been amended to include the limitation of claim 2 to conform with the amendment made to claims 1, 6 and 14. Claims 2 and 3 have been deleted.

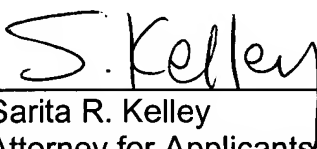
Amended independent claims 1, 6, 11, 13, 14, 20, 24 and 25 are outside the scope of Ruhe, Jr. because one R<sub>1</sub> and R<sub>2</sub> is polyisobutyl having about 5 to about 25 carbon atoms.

#### Conclusion

The amended claims of the present invention are clearly non-obvious over the Harrison et al. references and the Ruhe, Jr. reference because these references

neither teach, disclose nor suggest the use of the low molecular weight polyisobutene for making copolymers to obtain copolymers that are liquid at ambient temperature and which may be used in further applications, such as to prepare polymeric succinimides of the present invention, without the addition of heat or solvent. For these reasons, Applicants submit that this application is in condition for allowance and request that the Examiner reconsider this rejection and allow Claims 1-50 of this application.

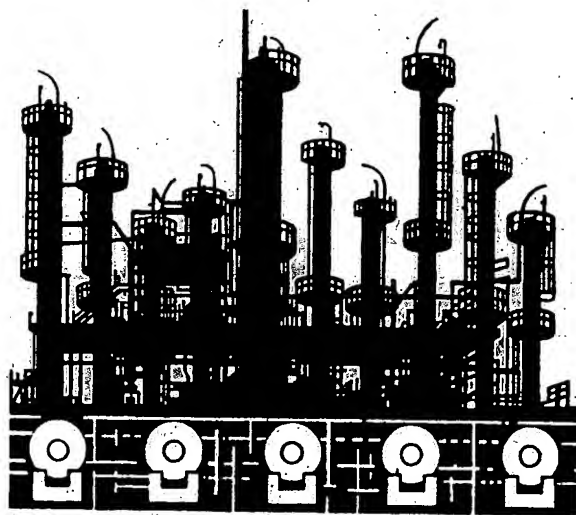
Respectfully submitted,

  
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Enclosures (Appendix A & B)

January 13, 2005

# **Appendix A**



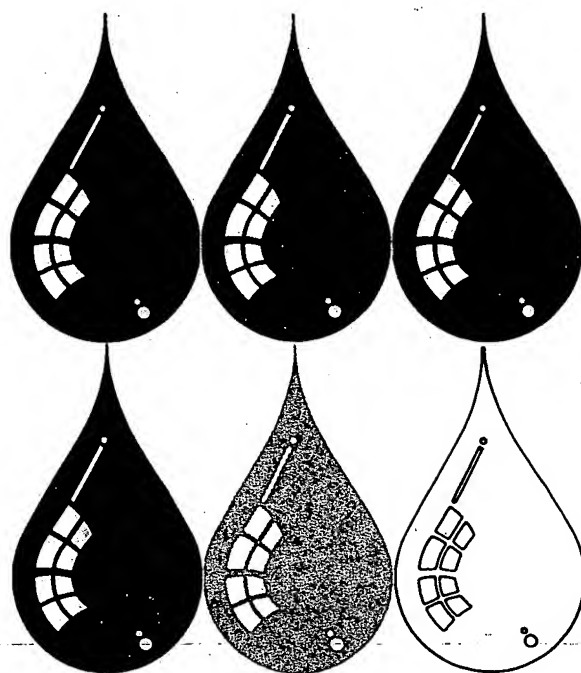
**Gulftene<sup>TM</sup> Alpha Olefins**

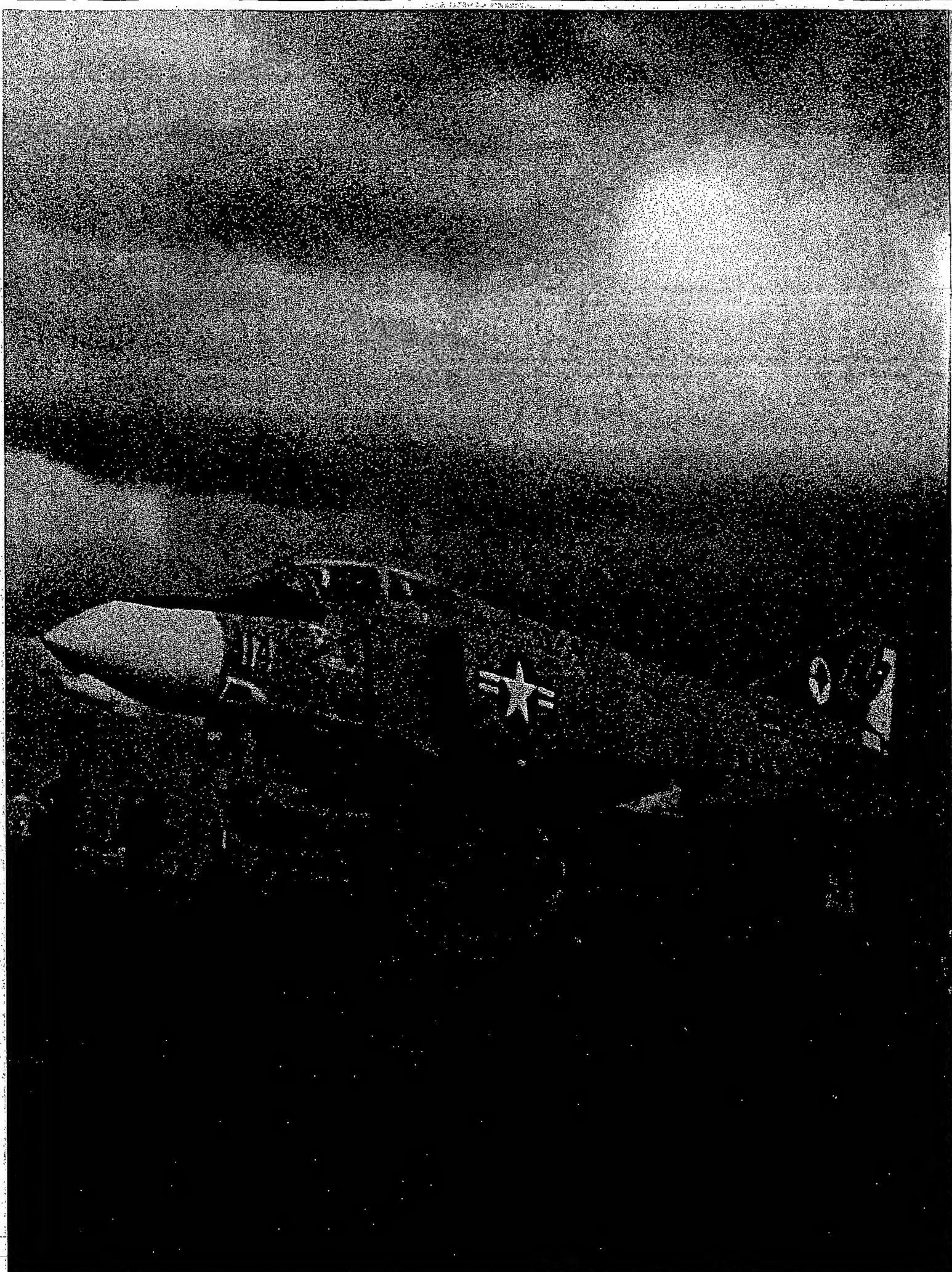




# Gulftene Alpha Olefins

	Chemical Name	Structure
Gulftene 4	Butene-1	$\begin{array}{c} \text{H} & \text{H} & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\text{C}-\text{C}=\text{CH} \\   &   & & \\ \text{H} & \text{H} & & \end{array}$
Gulftene 6	Hexene-1	$\begin{array}{c} \text{H} & (\text{H}) & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\left(\text{C}\right)-\text{C}=\text{CH} \\   &   & & \\ \text{H} & (\text{H})_3 & & \end{array}$
Gulftene 8	Octene-1	$\begin{array}{c} \text{H} & (\text{H}) & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\left(\text{C}\right)-\text{C}=\text{CH} \\   &   & & \\ \text{H} & (\text{H})_5 & & \end{array}$
Gulftene 10	Decene-1	$\begin{array}{c} \text{H} & (\text{H}) & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\left(\text{C}\right)-\text{C}=\text{CH} \\   &   & & \\ \text{H} & (\text{H})_7 & & \end{array}$
Gulftene 12	Dodecene-1	$\begin{array}{c} \text{H} & (\text{H}) & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\left(\text{C}\right)-\text{C}=\text{CH} \\   &   & & \\ \text{H} & (\text{H})_9 & & \end{array}$
Gulftene 14	Tetradecene-1	$\begin{array}{c} \text{H} & (\text{H}) & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\left(\text{C}\right)-\text{C}=\text{CH} \\   &   & & \\ \text{H} & (\text{H})_{11} & & \end{array}$
Gulftene 16	Hexadecene-1	$\begin{array}{c} \text{H} & (\text{H}) & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\left(\text{C}\right)-\text{C}=\text{CH} \\   &   & & \\ \text{H} & (\text{H})_{13} & & \end{array}$
Gulftene 18	Octadecene-1	$\begin{array}{c} \text{H} & (\text{H}) & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\left(\text{C}\right)-\text{C}=\text{CH} \\   &   & & \\ \text{H} & (\text{H})_{15} & & \end{array}$
Gulftene 20	Eicosene-1	$\begin{array}{c} \text{H} & (\text{H}) & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\left(\text{C}\right)-\text{C}=\text{CH} \\   &   & & \\ \text{H} & (\text{H})_{17} & & \end{array}$
Gulftene 20-24	Alpha Olefin C <sub>20-24</sub> Fraction	$\begin{array}{c} \text{H} & (\text{H}) & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\left(\text{C}\right)-\text{C}=\text{CH} \\   &   & & \\ \text{H} & (\text{H})_{17-21} & & \end{array}$
Gulftene 24-28	Alpha Olefin C <sub>24-28</sub> Fraction	$\begin{array}{c} \text{H} & (\text{H}) & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\left(\text{C}\right)-\text{C}=\text{CH} \\   &   & & \\ \text{H} & (\text{H})_{21-25} & & \end{array}$
Gulftene 30+	Alpha Olefin C <sub>30+</sub> Fraction	$\begin{array}{c} \text{H} & (\text{H}) & \text{H} & \text{H} \\   &   &   &   \\ \text{HC}-\left(\text{C}\right)-\text{C}=\text{CH} \\   &   & & \\ \text{H} & (\text{H})_{27+} & & \end{array}$





# I. Introduction

## Gulftene Alpha Olefins

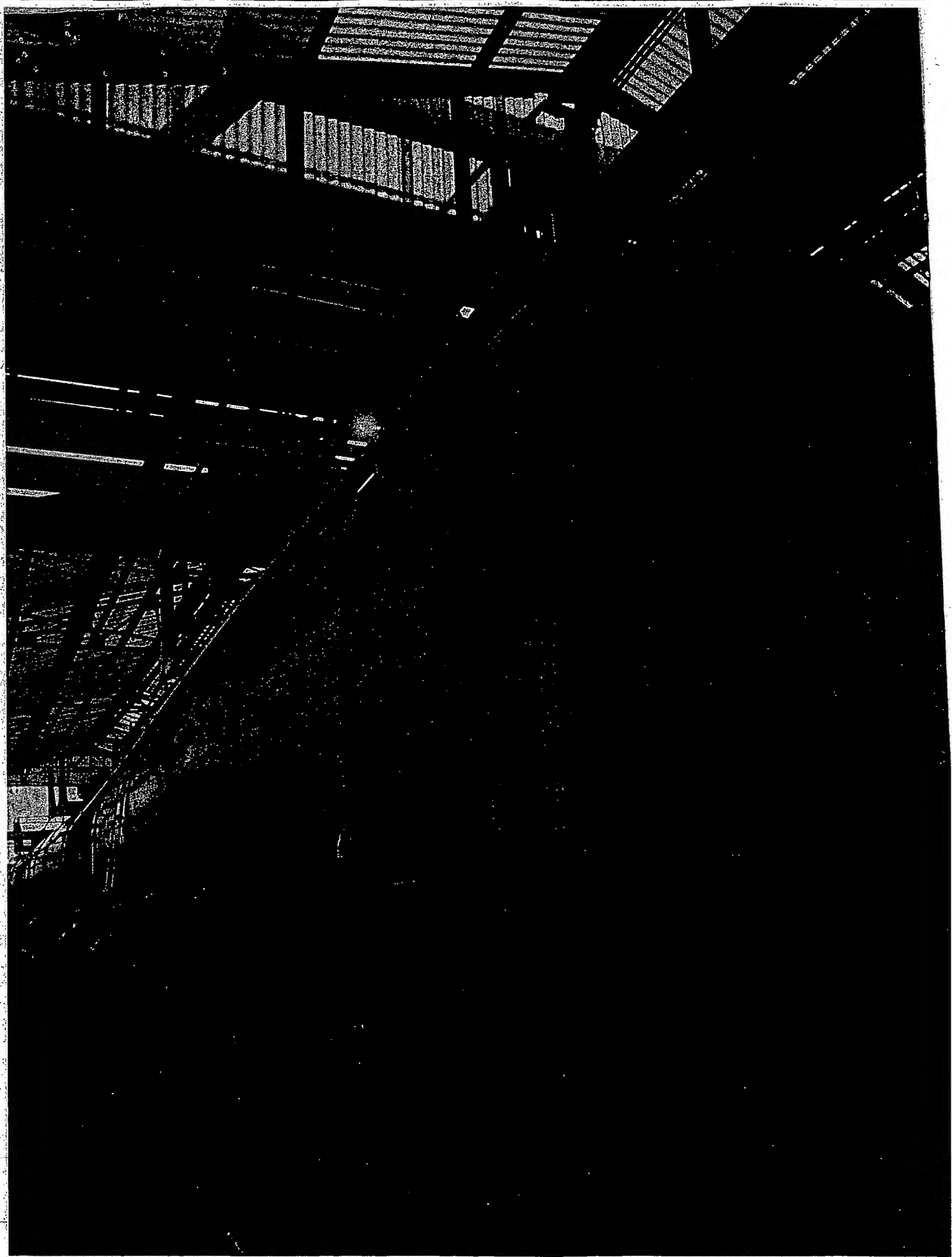
Gulftene is the registered trademark for alpha olefins manufactured by Gulf Oil Chemicals Company by Ziegler polymerization of ethylene. Gulf became the first manufacturer of commercial high-purity alpha olefins in 1966. With individual fractions from  $C_4$  to  $C_{30+}$ , GOCHEM still has the widest variety of alpha olefins available. Our quality—over 98% monoolefin content of the specified fraction—is to our knowledge not matched by any other producer.

Gulftene alpha olefins are used commercially to produce or upgrade polymers, detergents, lubricants and other consumer and industrial products. The terminal double bond provides a convenient site for conversion of the alpha olefin to intermediates or products of virtually any class of derivative.

Our plant at Cedar Bayou, Texas produces in excess of 120 million pounds of alpha olefins annually.



*Flame retardant hydraulic fluids derived from Gulftene alpha olefins are specified for the latest generations of fighting aircraft. U.S. Navy Photo.*



## II. Gulftene Properties and Shipment

Gulftene Alpha Olefins are clear liquids in the C<sub>6</sub>-C<sub>18</sub> range with a noticeable olefinic odor. C<sub>4</sub> is a gaseous product and C<sub>20+</sub> products are white, waxy solids. All resemble the corresponding paraffin in physical properties.

The even numbered alpha olefins below C<sub>20</sub> are available individually and custom blends can be prepared to customer requirements.

The Gulftenes are stored and shipped under nitrogen blanket to prevent peroxidation. Inhibitors such as DuPont 22, Ethyl 733, and Shell Ionol can be added at the rate of 10 pounds, 10 pounds, and 15 pounds per 1,000 barrels, respectively, to inhibit the formation of peroxide in the olefin products. The Cedar Bayou plant ships alpha olefins mostly by tank car and tank truck. However, 55-gallon, steel, epoxy-lined drums and 5-gallon pails are available for a slight additional charge. The Port of Houston is available nearby and export liftings can be made on request.

	Carbon Number										
	C <sub>4</sub>	C <sub>6</sub>	C <sub>8</sub>	C <sub>10</sub>	C <sub>12</sub>	C <sub>14</sub>	C <sub>16</sub>	C <sub>18</sub>	C <sub>20-24</sub>	C <sub>24-28</sub>	C <sub>30+</sub>
Monoolefin, %	98.6	98.6	98.6	98.6	98.6	98.6	98.6	98.6			
Alpha Olefin, %	98.5	97.0	96.1	95.2	94.0	93.0	92.0	90.8			
Saturates, %	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4		
Flash °F	—	60	60	120	180	225	270	310	375*	380*	510*
P-M	—	—	—	—	—	—	4	18	110	145	180
Melting Point °F	—	—	—	—	—	—	—	—	—	—	—
Specific Gravity 60°/60°F	—	.678	.719	.745	.763	.776	.785	.792	.799	.819	
Distillation 5% °C	—	60	118	164	205	240	270				
95% °C	—	66	128	175	220	255	300				

\* Flash COC

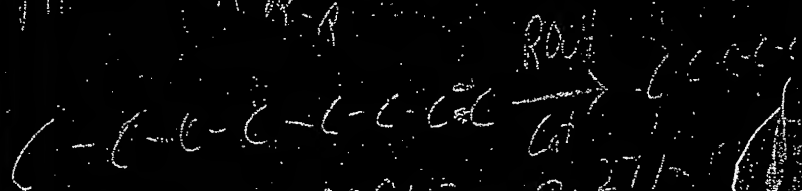


Shipment by tankcar or drum or tank truck may be arranged.

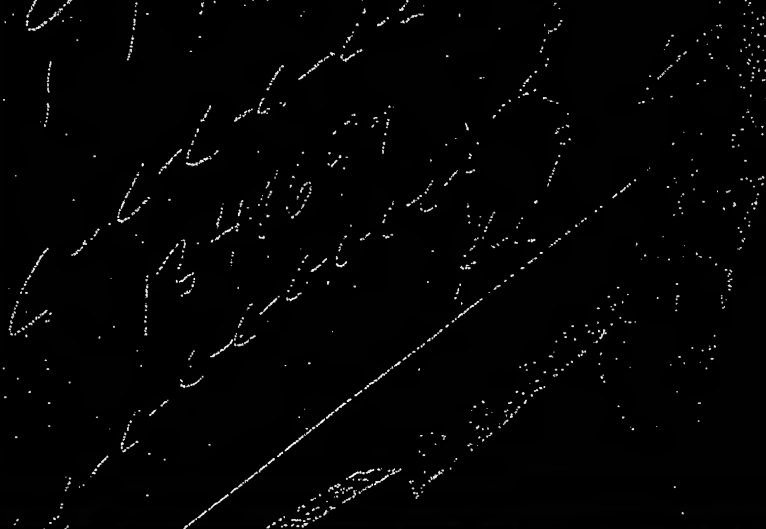
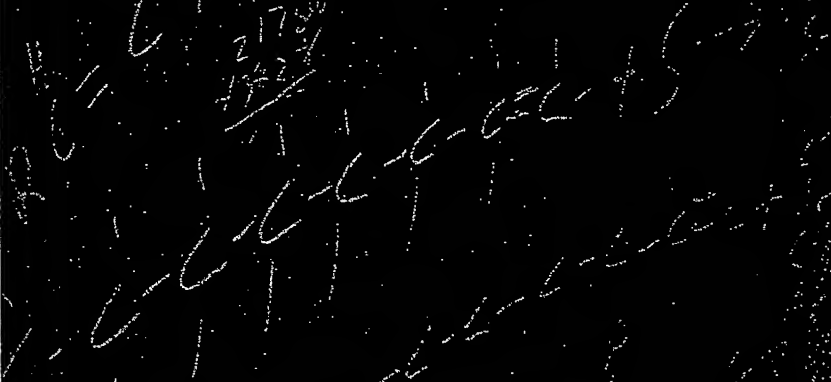
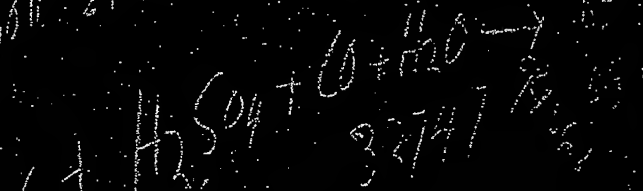
3740



180°C F 240°C



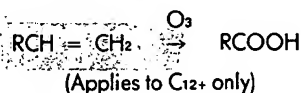
III  $2115X + 279 + 13W = 2 + 271$



# III. Typical Reactions of Gulfenes

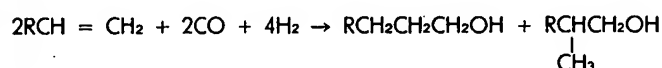
## Ozonolysis

The oxidation of alpha olefins with ozone can be carried out to produce a mixture of acids composed predominantly of an acid one carbon less than the charge olefin.



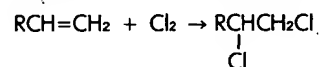
## Carboxylation

The Oxo reaction produces a primary alcohol one carbon higher than the chain length of the olefin charge stock. The intermediate stage in the reaction is a mixture of aldehydes. The aldehydes on hydrogenation yield a mixture of isomeric alcohols.



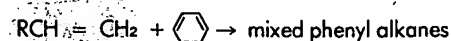
## Addition of Halogens

The elemental halogens will add to the double bond of an olefin to yield a dihalide. When chlorine or bromine is used, alpha olefins will usually yield a 1, 2-dihalide as the principal product.



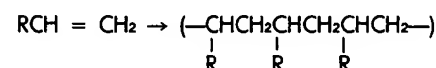
## Alkylation with Alpha Olefins

Aromatics are readily alkylated with alpha olefins and the resulting products are useful intermediates for production of surface-active agents. Benzene alkylated with a specific alpha olefin will form a mixture of secondary alkyl benzenes.



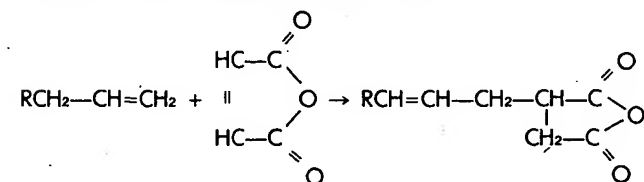
## Polymerization

The polymerization of the alpha olefin can be accomplished. Polybutene-1 has been commercialized, and is being used for pipe and film products. Higher alpha olefins can be similarly polymerized to yield unique new polymers.



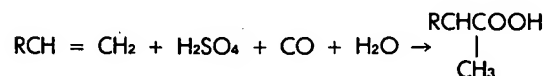
## Addition of Maleic Anhydride

The addition of alpha olefins from six to thirty carbon atoms has been described.



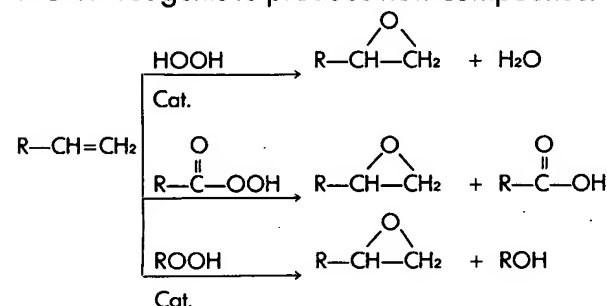
## Carboxylation

Olefins can be converted to one carbon higher acids by carboxylation with carbon monoxide.



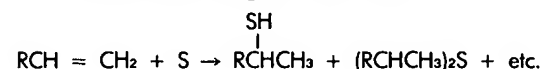
## Epoxidation and Hydroxylation

Fairly mild oxidation conditions may be employed to produce long chain epoxides. These epoxides while useful in themselves, may be reacted with a variety of other reagents to produce new compounds.



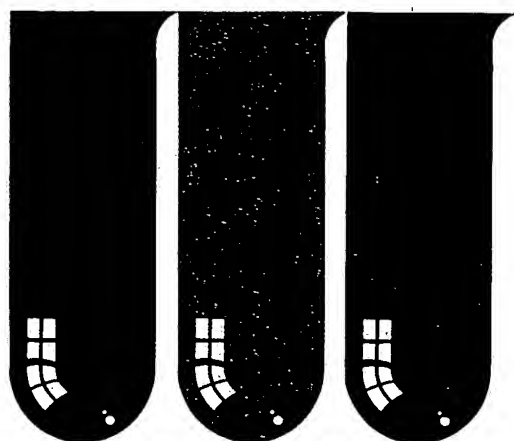
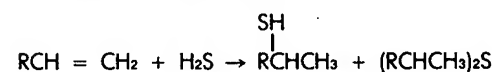
## Addition of Sulfur

The addition of sulfur to olefins yields a variety of compounds as product including mercaptans, di- and polysulfides. It has been suggested that the sulfur strips hydrogen from unsaturates to form hydrogen sulfide, a part of which adds to more of the unsaturates to give a sulfide.

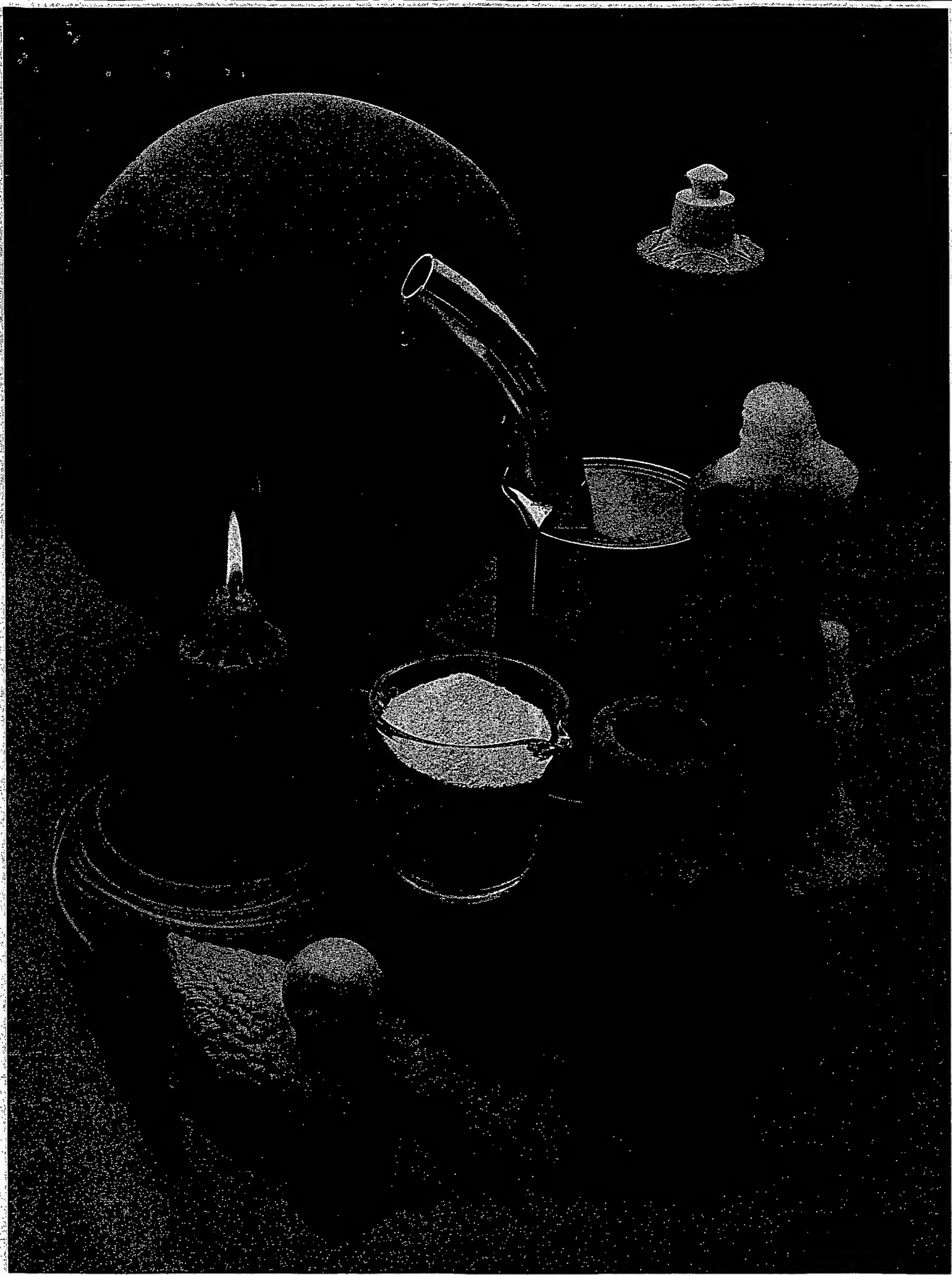


## Addition of Hydrogen Sulfide

The addition of hydrogen sulfide to alpha olefins takes place readily and will follow Markownikoff's rule. Mercaptans and sulfides both are formed. The relative yields of each can be influenced by selection of reaction conditions.









## IV. Applications

Gulftene linear alpha olefins produced from Gulf high purity ethylene are low in impurities and adaptive for a wide range of commercial products. The terminal double bond will react readily with a wide variety of chemicals as noted in the previous reaction section.

Primary commercial markets for the reacted Gulftenes are in detergents, lubricants and fluids, and polymers. In each of these market areas several different derivatives of Gulftenes can be produced to fit special requirements. In lubricants, for example, synthetic base fluids can be made from polyalphaolefins, from polyol esters of acids from Gulftenes, or from dialkylbenzene made with Gulftenes. These uses and others are discussed under market applications. Gulftenes can also be used to synthesize almost anything where an even numbered straight carbon chain from C<sub>4</sub> to C<sub>30+</sub> is required. When you need a special chemical product with a straight carbon chain as part of the total molecule, it can be made with Gulftenes.

### A. Detergents

Gulftenes lead to a diverse variety of detergents. Alpha olefin sulfonates are readily produced with sulfur trioxide using commercial continuous sulfonation units. These sulfonates offer excellent detergency, mildness, rapid biodegradability, compatibility with hard water and good wetting and foaming properties. They make high-quality shampoos, light-duty liquids, bubble baths and heavy-duty liquids and powders.

Alkanesulfonates are readily made from Gulftenes by addition of an alkaline bisulfite under free radical conditions. These products have low solubility which suggest their use in syndet toilet bars.

Gulftenes can be converted to primary alcohols which can then be made into nonionic ethoxylates or anionic ethoxysulfates.

Amines can be prepared from Gulftenes. Various amine derivatives are used commercially for fabric softeners, corrosion inhibitors, biocides and sanitizers.

### 1. Alpha Olefin Sulfonation

In recent years, the detergent industry has shown increasing interest in alpha olefin sulfonates for surfactant systems. Gulf Oil Chemicals Company has supported this interest with technical service to those companies in the sulfonation and detergent industries, including a sulfonation pilot plant at Gulf's Harmarville, Pennsylvania, Research Laboratories.

Many of the results of our work with alpha olefin sulfonation follow with suggested guidelines for preparing alpha olefin sulfonates.

Experience at Gulf Research has shown that alpha olefins can best be sulfonated using continuous, thin-film reactors employing gaseous SO<sub>3</sub>. Batch-type equipment, such as the Jergens reactor, does not yield a satisfactory product. Sulfonation reagents such as oleum and chlorosulfonic acid are unsuitable.

In the thin-film sulfonation unit (Figure 1), the alpha olefin and a dilute mixture of SO<sub>3</sub> in air are fed through a specially designed reactor head. Reaction takes place on the reactor wall and the heat of reaction is removed by cooling water in the jacket. Sulfonated olefin liquids are separated from the gas at the bottom of the reactor.

The sulfonated olefins are then neutralized with aqueous sodium hydroxide to produce a solution or slurry of detergent. Optimum neutralization conditions are 350° F, 120 psig, a residence time of 10-20 minutes, and 10 mole % excess of NaOH. The product will have a pH of about 11-12. The alpha olefin sulfonate can be stored at a pH of about 10, but is adjusted to a pH of 7.5-8 before final use.

Optimum reaction conditions are somewhat dependent upon the carbon number of the alpha olefin. The following conditions should produce an alpha olefin sulfonate, in the C<sub>14</sub>-C<sub>16</sub>-C<sub>18</sub> carbon range, with a Klett color below 100 (without bleaching) and a neutral oil content below 2%.

### Unit Operating Conditions

SO <sub>3</sub> /olefin molar ratio	1.03-1.07
Air rate/sq. in. of reactor cross section, SCFM	50-60
Cooling water temperature	0-35° C
Olefin feed rate, lb/hr (for 1"x22' reactor)	40-50



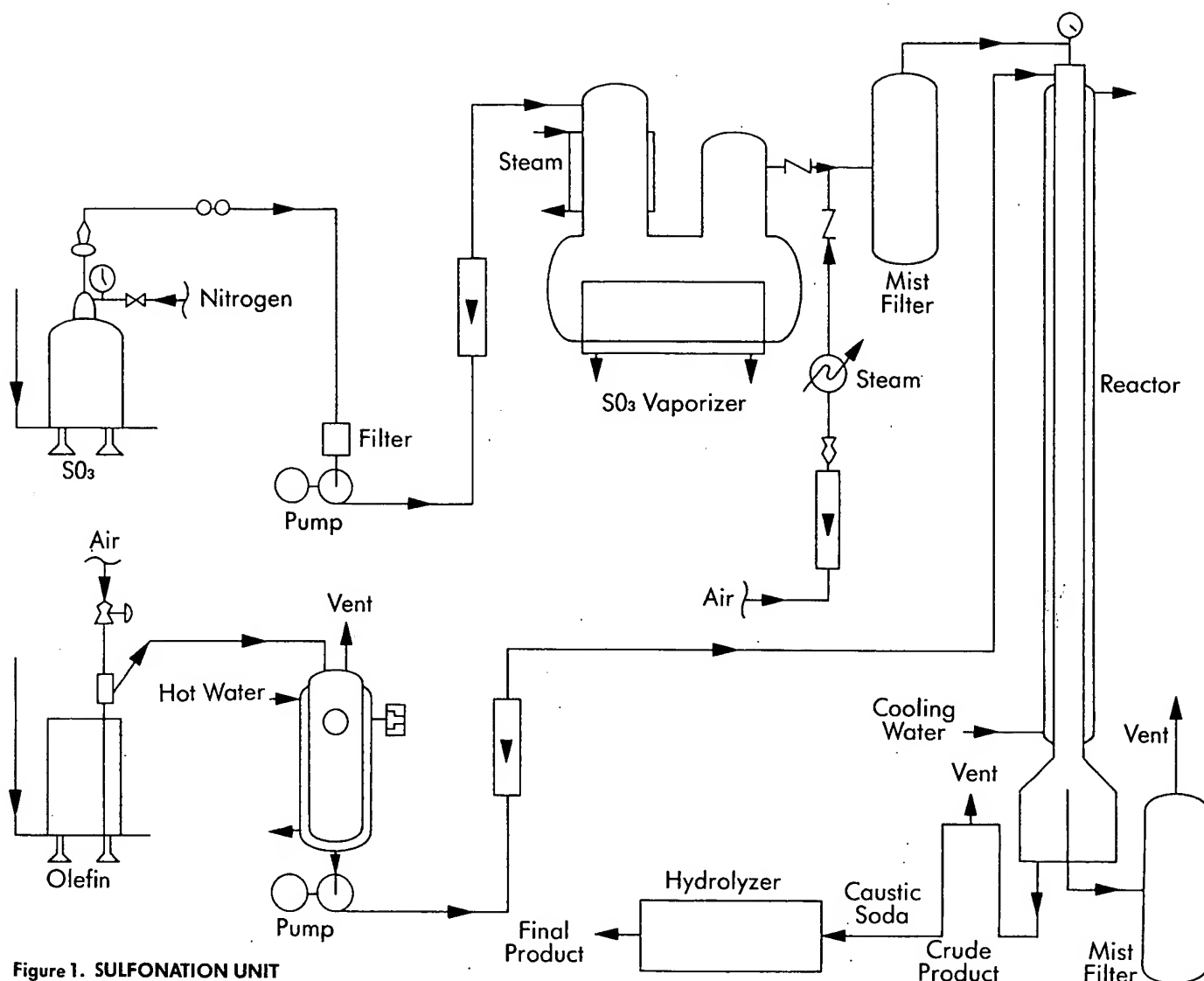


Figure 1. SULFONATION UNIT

## 2. Alpha Olefin Sulfonates

Alpha olefin sulfonates have properties not found in other detergents. Their ease of biological degradation exceeds the rates obtained with linear alkylate sulfonates (Figure 2). Solubility is good and better than that of *n*-alkyl sulfates and alkanesulfonates. The viscosity of aqueous mixtures at moderate concentrations is low, which permits ease in processing and handling. Resistance to precipitation by water hardness and other metallic ions is very good and superior to alkanesulfonates. Detergency of cotton is comparable to the best commercial alkylbenzene sulfonates and definitely superior to the lower molecular weight dodecylbenzene sulfonates (Figures 3

and 4). Since the detergency of alpha olefin sulfonates is dependent on the average carbon number of a blend rather than on its particular make-up, the composition can be altered to achieve desired overall performance characteristics. Blends containing sulfonates from alpha hexadecene to alpha eicosene lend high detergency to heavy-duty products. Foaming ability (Figures 5 and 6) is excellent and comparable to alcohol ethoxy sulfates. Alpha tetradecene and alpha hexadecene sulfonates are applicable for light-duty products and show excellent foam stability in hand dishwashing (Figures 7, 8 and 9).

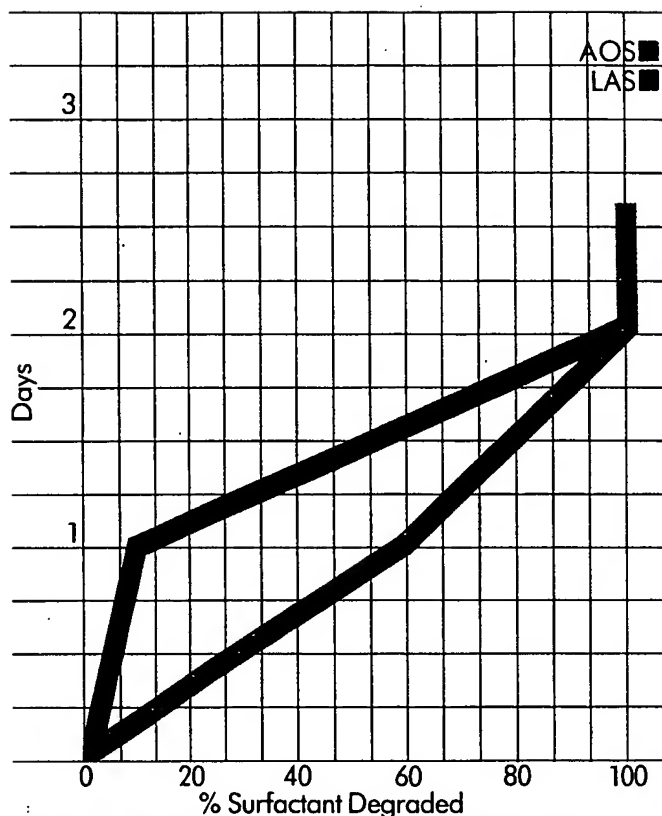


Figure 2. BIOLOGICAL DEGRADATION BY THE SHAKE FLASK CULTURE TECHNIQUE

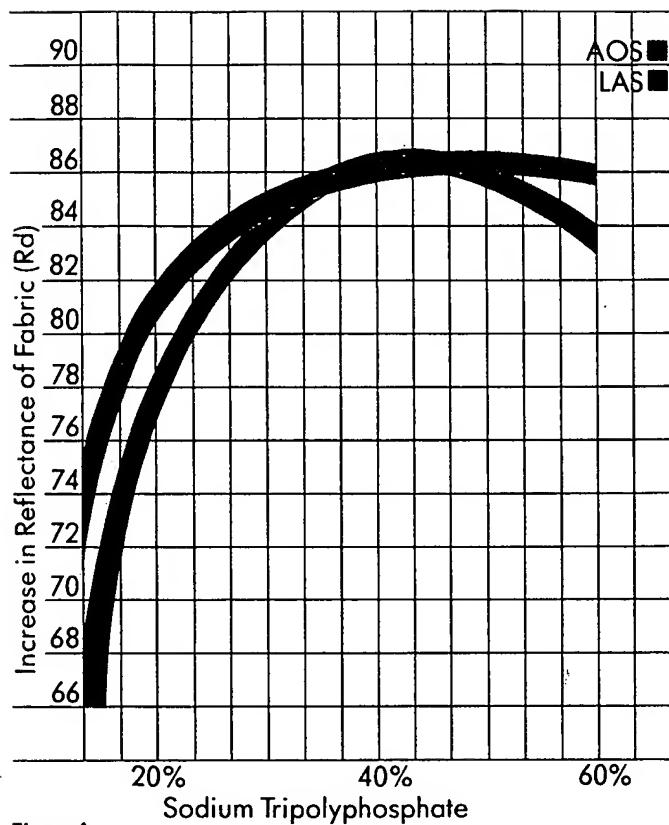


Figure 4. DETERGENCY OF COTTON

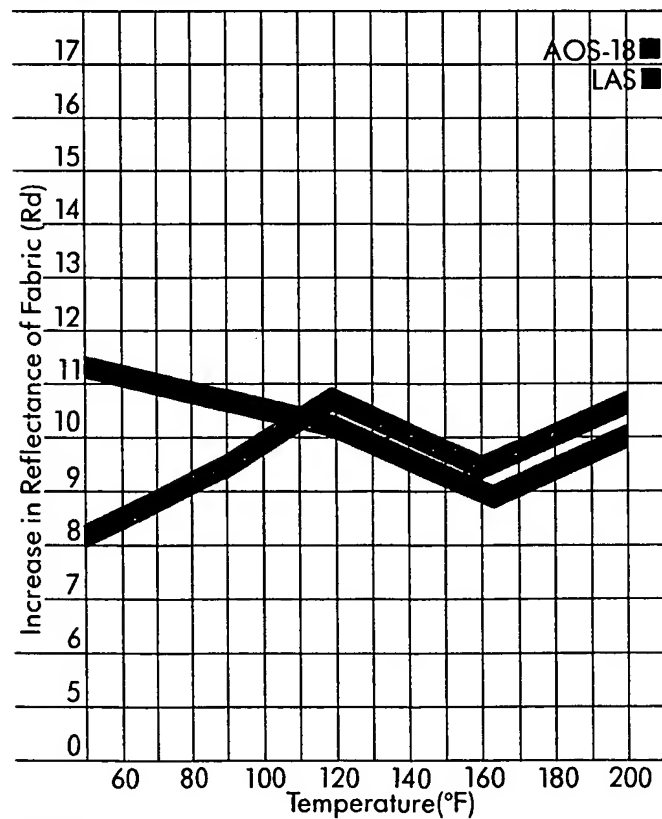


Figure 3. DETERGENCY OF COTTON

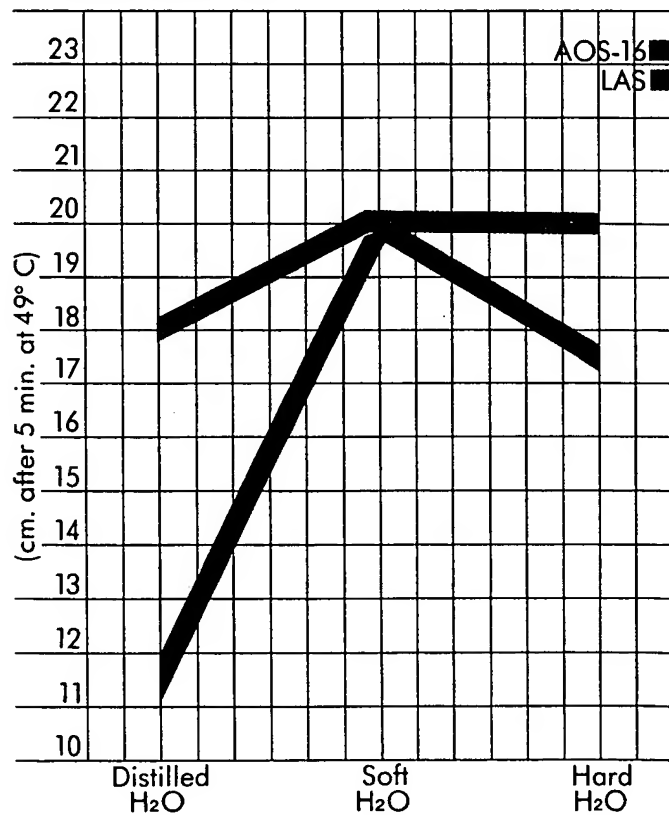


Figure 5. FOAMING ABILITY (0.05% Concentrate) Ross-Miles Method (ASTMD-1173)

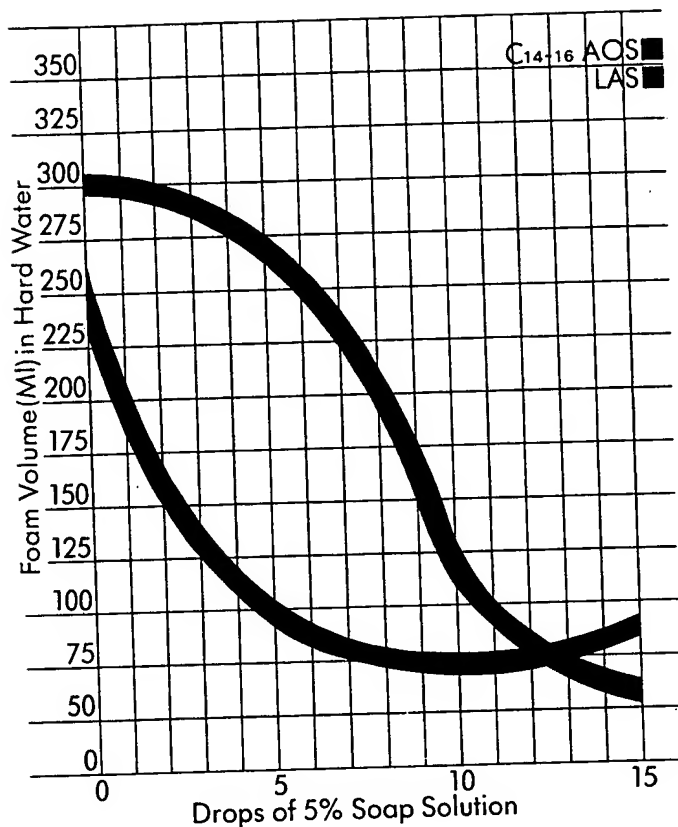


Figure 6.  
FOAMABILITY IN PRESENCE OF SOAP

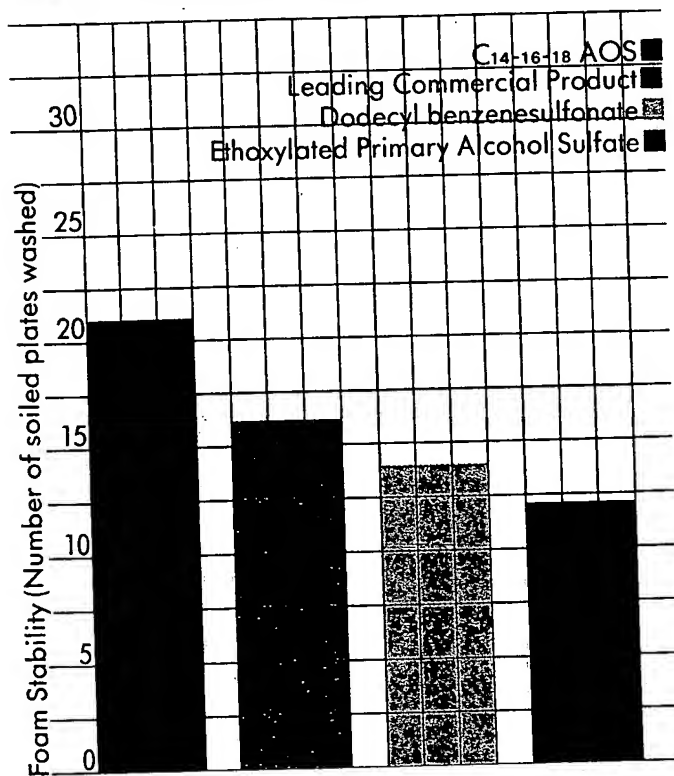


Figure 7.  
DISHWASHING FOAM PERFORMANCE

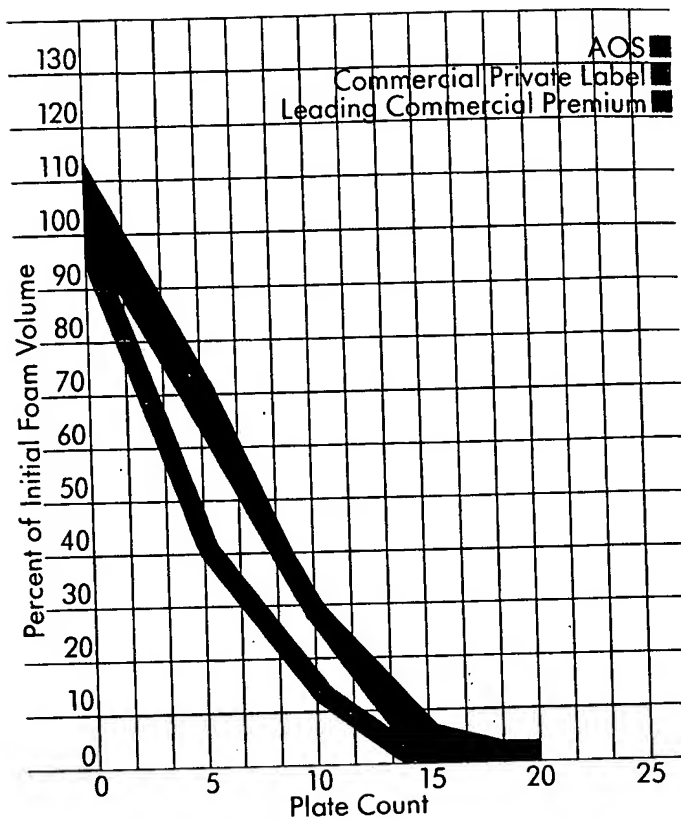


Figure 8.  
FOAM STABILITY BY DISHWASHING

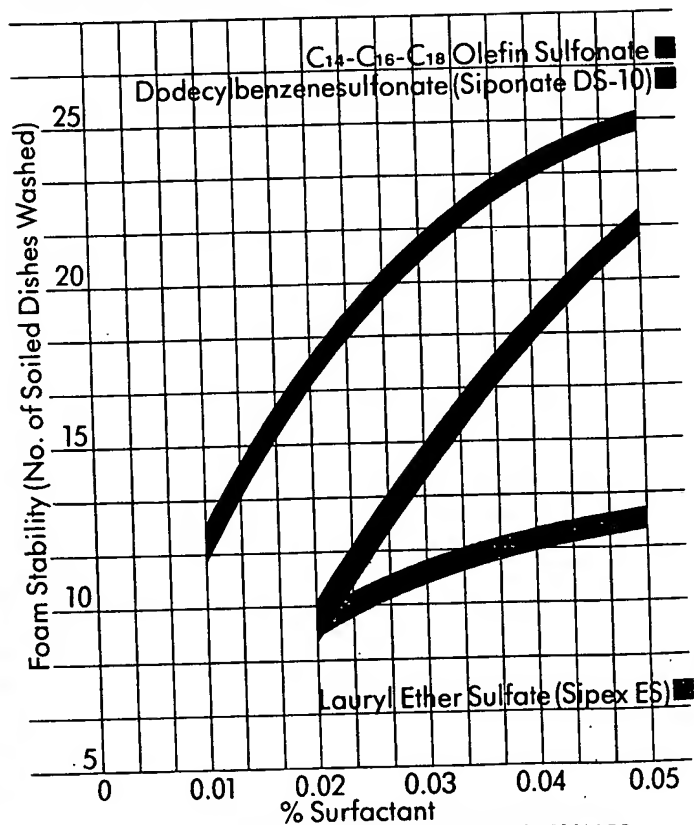


Figure 9. EFFECT OF CONCENTRATION ON PERFORMANCE  
OF SURFACTANTS  
Water Hardness—150 ppm

### 3. Shampoos

Gulftene alpha olefins may be converted to sulfonates for use in shampoos. Investigation of alpha olefin sulfonates by Gulf Research personnel shows that C<sub>14</sub> and C<sub>14-16</sub> alpha olefin sulfonate blends perform particularly well.

In three critical areas of shampoo performance, these alpha olefin sulfonates perform as well as or better than conventional shampoo surfactant systems.

#### Foaming ability

The foaming ability of C<sub>14</sub> and C<sub>14-16</sub> alpha olefin sulfonates in the presence of synthetic hair oil is equal to that of lauryl sulfate and lauryl ethoxy (1) sulfate and superior to lauryl ethoxy (3) sulfate and linear alkylbenzene sulfonate (LAS). In the presence of synthetic body oils (sebum), C<sub>14</sub> and C<sub>14-16</sub> alpha olefin sulfonates are comparable in foaming ability to lauryl sulfate and lauryl ethoxy (3) sulfate and superior to LAS.

#### Foam stability

C<sub>14</sub> and C<sub>14-16</sub> alpha olefin sulfonates perform about as well as or slightly better than lauryl sulfate. Higher olefin sulfonates, such as C<sub>16</sub> and C<sub>18</sub>, do not maintain foam as well as lauryl sulfate.

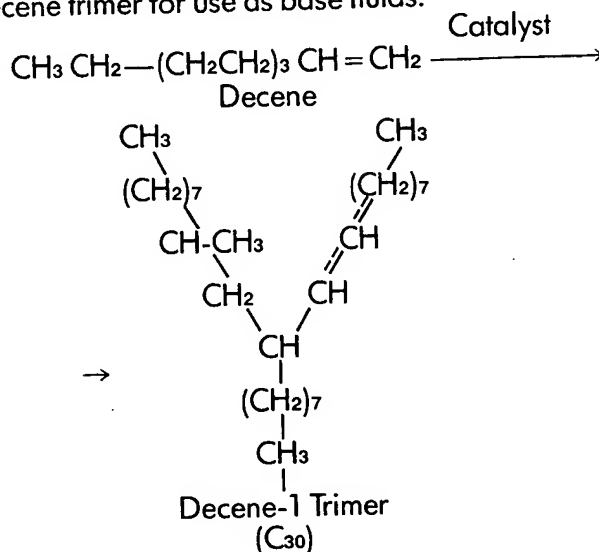
#### Hard water tolerance

Another important advantage of alpha olefin sulfonates in shampoo formulations is their resistance to precipitation by hard water. Olefin sulfonates in the C<sub>14</sub> and C<sub>14-16</sub> range show a distinct advantage over lauryl sulfate in tolerance to very hard water.

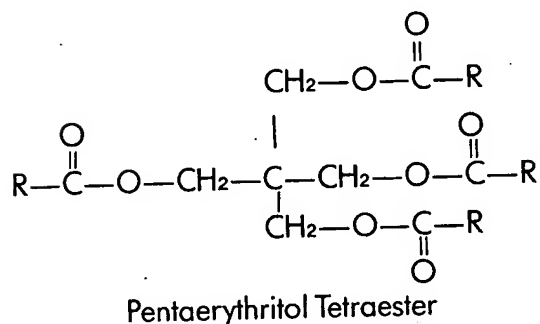
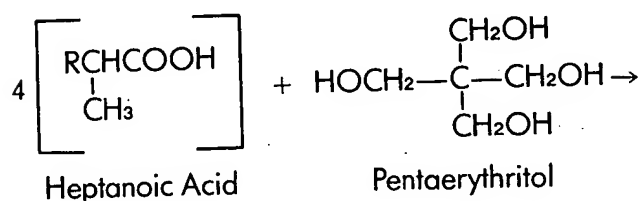
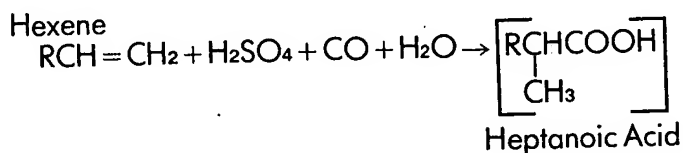
Sulfonates derived from Gulftene alpha olefins have excellent solubility. Neutralization of the olefin sulfonate with caustic soda produces a product more soluble than sodium lauryl sulfate, and in the latter case resort is made to the more expensive alkanolamine salts to achieve adequate solubility. For example, the cloud points of C<sub>14</sub> and C<sub>14-16</sub> olefin sulfonate solutions are -5° and 0° C, respectively. Cloud points of the sodium salts of lauryl sulfate are typically higher than for alpha olefin sulfonates, and may be decreased only by the use of more expensive triethanolamine salts.

### B. Synthetic Lubricants and Functional Fluids


Synthetic base fluids for lubricating oils can be prepared by catalyzed oligomerization of Gulftene alpha olefins. Decene in particular is polymerized to decene trimer for use as base fluids.

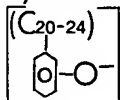


Gulftene alpha olefins yield odd-numbered acids upon carboxylation. Polyol esters are then prepared by reacting acids with polyols such as pentaerythritol.



The esters are used as additives to other lubricants or as base fluid for synthetics. They offer wide temperature tolerance similar to the oligomerized alpha olefins.

Phenol or benzene can be alkylated with Gulftene alpha olefins. Alkylbenzene sulfonates are excellent detergents as additives in lubricating oils. Dialkylbenzene ( $C_{10}$  or  $12$    $C_{10}$  or  $12$ ) has useful properties as a synthetic fluid and lubricant. Phenate (alkyl phenol)  $[(C_{20-24})$



$]_2Ca^{++}$  is another derivative used for lube additives. Chlorinated alpha olefins are very stable and useful as extreme pressure additives in metal working fluids.

### 1. Polyalphaolefin lubricants and synthetic fluids

The polyalphaolefin fluids, for example Synfluid<sup>®</sup> produced by GOCHEM, are used as base fluids for compounding with additives to form high performance lubricants. Polyalphaolefins offer advantages of:

1. Good low temperature viscosity (Figure 10)
2. Long service life and better stability (Figure 11)
3. High inherent viscosity index
4. Low volatility
5. Compatibility with natural oils and other synthetic base fluids

These advantages can confer superior properties to engine lubricants and hydraulic fluids used in aviation, automotive and industrial applications.

### 2. Alkylation with Gulf Alpha Olefins

Gulftene alpha olefins have been successfully employed in the alkylation of various aromatic species. Alpha olefin alkylates of benzene and phenol have been prepared and evaluated.

Alkylation of aromatics with any of the Gulf alpha olefins is basically a Lewis-acid-catalyzed, Friedel-Crafts reaction. Aluminum trichloride is the preferred acid for benzene alkylation, although higher yields have been obtained with anhydrous hydrofluoric acid. Alkylation of phenol with alpha olefins seems to proceed best when boron trifluoride is used. Anhydrous HF has been reported in naphthalene alkylations.

Bench scale preparations of alpha olefin alkylate have been performed at Gulf's research labs. Typical preparations are:

#### Benzene Alkylation

Benzene alkylation with octene-1 was performed in standard laboratory glassware using commercially available octene-1. The benzene was dried to a

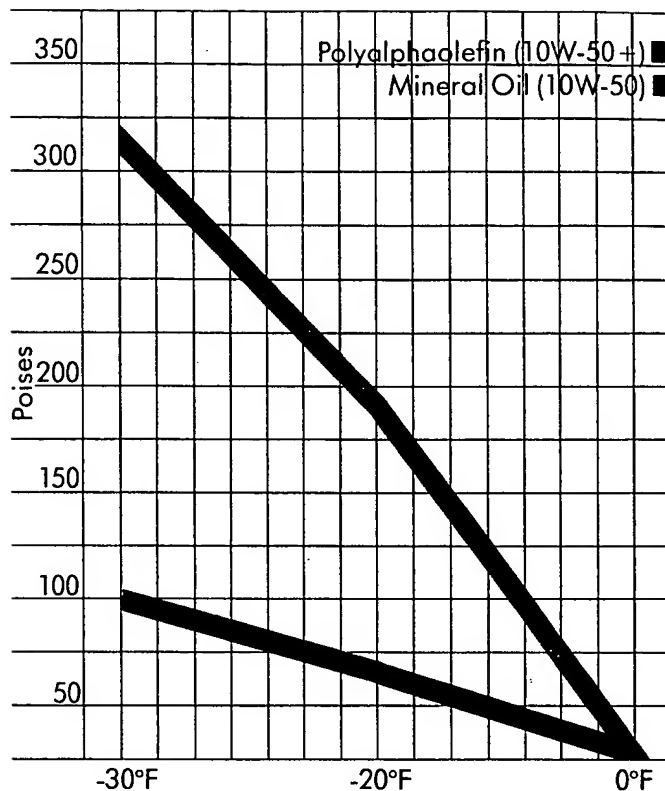


Figure 10.  
LOW TEMPERATURE VISCOSITY

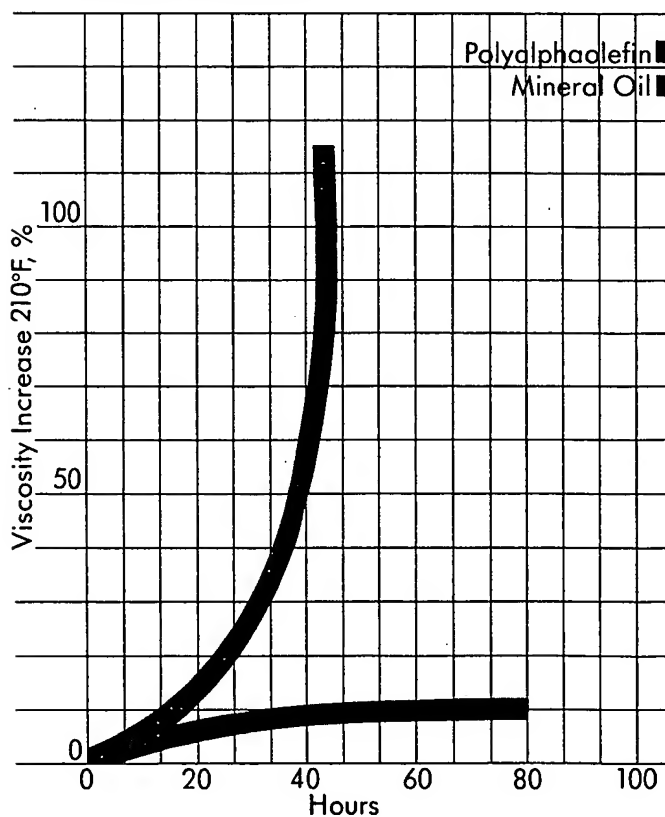


Figure 11.  
TEMPERATURE STABILITY

moisture content of 65 ppm by azeotropic distillation. Typically, one part of olefin was added, over 45 minutes, to a stirred mixture of 6.5 parts of benzene containing 0.6% of anhydrous aluminum chloride based on the weight of reactants. The temperature was approximately 45°C. After completion of olefin addition, stirring was continued for five minutes. The reaction products were decanted from the solid catalyst residue after a 15 minute settling period. The reaction products were washed with either dilute caustic or hydrochloric acid followed by water. The water was analyzed by gas chromatography. The alkylate was recovered by fractionation distillation at 60 mm Hg pressure.

### Phenol Alkylation

The following preparation of a C<sub>10</sub> alpha olefin alkylphenol is generally applicable to lower molecular weight alpha olefins. Some modification in reaction conditions is necessary for alkylation employing higher molecular weight alpha olefins.

A phenol/alpha olefin ratio of 2/1, mol/mol was employed in order to inhibit the formation of dialkylate. Figure 12 indicates the effect of reactant ratio on product composition. The 2/1 molar ratio results in a product which is 76% monoalkylate, 23% dialkylate and 1% trialkylate. The use of higher phenol/olefin ratios will result in an increased percentage of monoalkylate. However, higher monoalkylate concentration must be balanced against energy expended in phenol separation and in the cost of discarded quantities of phenol.

Aromatics alkylated with Gulf alpha olefins have numerous applications in the chemical and allied industries. Alkylation of benzene with detergent range alpha olefins yields linear alkylate for detergent applications. The primary use of these products will be as detergent intermediates sulfonated to surface active agents.

Alkylation of phenols with Gulf alpha olefins yields products with numerous commercial applications including antioxidants, lube oil additives, plasticizers, and surface active agents. In the area of surface active agents, ethoxylation of phenols alkylated with higher molecular weight Gulf alpha olefins is of particular promise. A separate Gulf product application bulletin describes in detail the surfactant properties of ethoxylated linear alkyl phenols.

### C. Polymers

Gulftene C<sub>4</sub>, C<sub>6</sub> and C<sub>8</sub> alpha olefins are useful to form improved high density polyethylene homopolymers. Gulf butene, hexene and octene are very high-purity products and free of catalyst poisons.

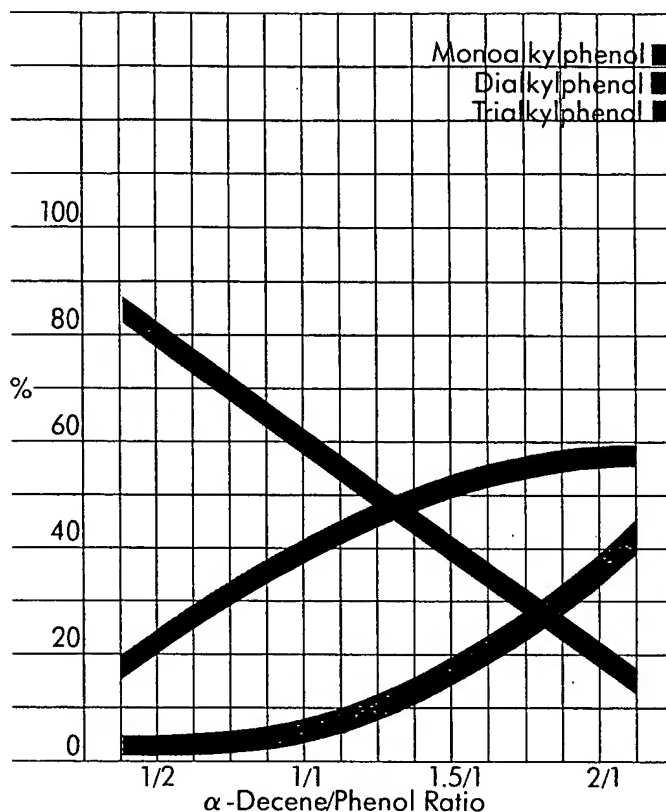
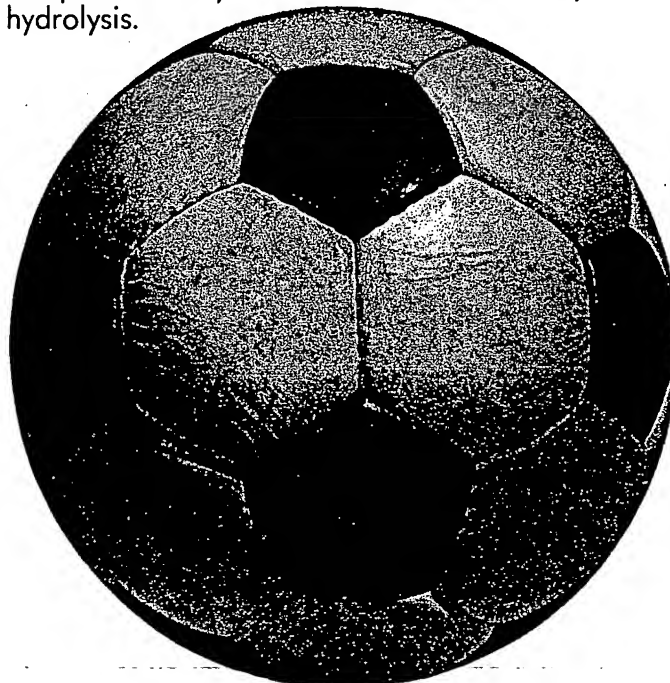


Figure 12.  
EFFECT OF REACTANT RATIO ON PRODUCT COMPOSITION  
IN THE DIALKYLATION OF PHENOL WITH  $\alpha$ -DECENE

Linear alcohols are readily formed from these Gulftene alpha olefins (C<sub>6</sub>, C<sub>8</sub>, C<sub>10</sub>) and can be made into superior linear phthalate esters for plasticizers. The alcohols can be formed by the oxo process or hydrobromination followed by hydrolysis.



Gulftene 4 can be polymerized to polybutene. Polybutene has several properties that make it ideally suited for many engineering applications. Among the most outstanding are its long-term mechanical properties. Creep resistance is excellent for a semi-crystalline polyolefin; in fact, PB behaves more like a crosslinked plastic. And in addition, PB shows no signs of cracking, crazing or fracturing when stressed below its short-time failure stress value for long periods of time. It exhibits a unique combination of good tensile and tear properties. The tensile breaking strength is very high for a polyolefin, and its tear strength depends greatly upon tear rate, increasing rapidly with increased tear rate.

Polybutene is less sensitive to commonly known surface cracking chemicals, such as environmental stress-cracking agents. It needs protection, however, from ultraviolet light and certain corrosion agents that commonly degrade polyolefins. Ultraviolet light stability can be improved with screening agents and stabilizers.

Gulftene 20-24 can be chlorinated for use as a secondary plasticizer where it contributes to flame retardation. Alpha olefins chlorinate more readily than paraffins due to the double bond.

Gulftene 6, 8 and 10 ( $C_6$ ,  $C_8$ ,  $C_{10}$ ) have been co- and terpolymerized with vinyl acetate and vinyl chloride.

Gulftenes can be used as a copolymer with acrylonitrile to form a polymer with interesting properties.

Copolymers of maleic acid and Gulftene's 4 through 18 ( $C_4$ - $C_{18}$ ) can be formed using peroxides as catalysts. The products are resins of interest for paper sizing, sheet molding compounds, etc.

### 1. Polyethylene Copolymers

High density polyethylene homopolymers are known to be deficient in their ability to resist environmental stress-cracking (ESCR). Although this problem may be minimized by producing a polymer with a low melt index (high melt viscosity), copolymerization using Gulftene-6 (hexene-1) offers a unique solution. In many polymer applications, such as blow molding, high flow rates are called for, and a material with a low melt index becomes a liability. Addition of Gulf hexene-1 as a comonomer will allow a polymer to be formed that exhibits very good flow properties while retaining a low melt index. In addition, the ESCR of the material is greatly increased.

Gulftene-6 has been found to be superior in improving the ESCR of particle form polymers. Gulftene-8 (octene-1) alpha olefin can also be used in this application and is as effective as Gulftene-6 in increasing the ESCR of the polymer. However, to achieve higher polymer densities, a higher concentration of Gulftene-8 is required.

Comparative tests using the Gulf Ziegler-derived Gulftene-6 and a hexene-1 obtained via wax-cracking point out the advantages of the high-purity Gulf material. In two different runs, each using identical amounts of each olefin, the productivity (pound of polymer formed per pound of  $C_6$  used) of the Gulftene-6 was over twice that of the wax-cracked olefin. The Gulf material was determined to be free of catalyst poisons, and the finished polymer showed better incorporation of comonomer.

Gulftene-6 comonomer can be used under the same reaction conditions as Gulftene-4. Catalyst productivity and reaction temperature/melt index relationships are unchanged. However, ESCR is substantially increased with Gulftene-6 versus Gulftene-4. For example, at a polymer density of 0.95 and melt index ranges of 0.20 to 0.30, Butene-1

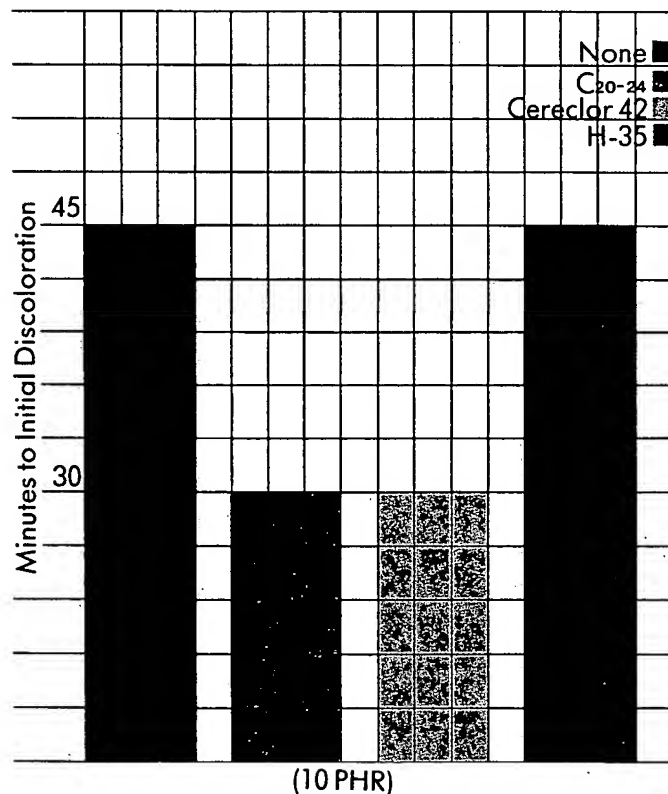


Figure 13.  
OVEN HEAT STABILITY



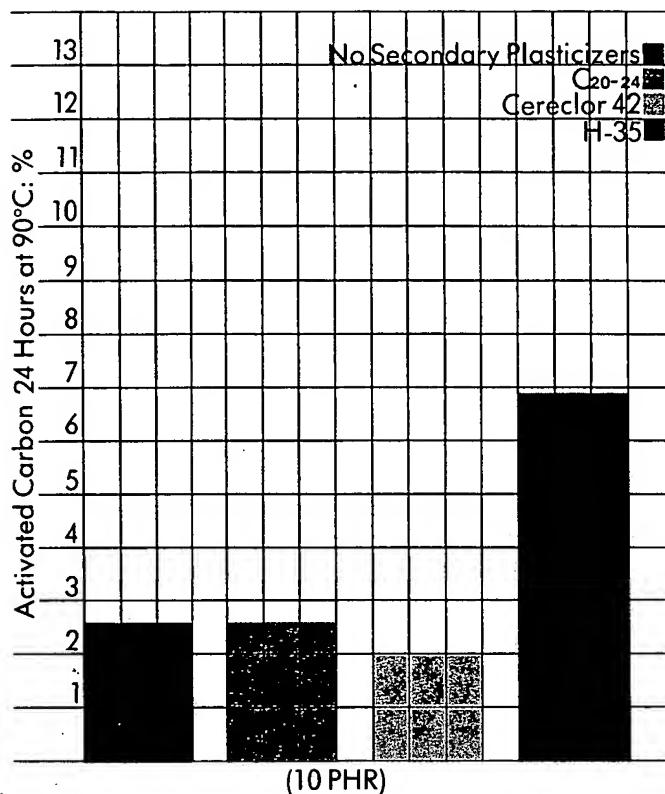


Figure 14. VOLATILITY COMPARISON OF CHLORINATED C<sub>20-24</sub> WITH OTHER COMMERCIAL SECONDARY PLASTICIZERS

copolymers had ESCR values of from 50 to 310 hours. Hexene-1 exhibited Bell ESCR values of from 800 to more than 1,000 hours under the same conditions. Overall, Hexene-1 will improve polymer ESCR values without sacrificing polymer yield processability, or other polymer properties.

## 2. Chlorinated Alpha Olefins

Gulf Oil Chemicals Company has evaluated a 40% chlorinated Gulftene 20-24 (C<sub>20-24</sub> alpha olefin) as a secondary plasticizer in PVC formulations. This alpha olefin derivative was evaluated in comparison with ICI's Cereclor 42 (42% chlorinated paraffin) and Conoco's H-35 (alkyl-aryl hydrocarbon).

The evaluation of the mechanical properties of the formulations show that the chlorinated Gulftene alpha olefin is equivalent in plasticizing efficiency to the two other secondary plasticizers evaluated. The results are shown in Figures 13 and 14. In heat stability, the chlorinated Gulftene 20-24 is similar to Cereclor 42 and not quite as good as H-35. The volatility of chlorinated Gulftene 20-24 is better than that of H-35 but slightly poorer than Cereclor 42 (Figure 14).

The evaluation indicates that the 40% chlorinated C<sub>20-24</sub> alpha olefin is an acceptable secondary plasticizer for PVC.

## D. Miscellaneous Applications

Mercaptans can be formed by the addition of hydrogen sulfide to alpha olefins under proper conditions. These mercaptans are useful for rubber additives and specialty chemicals.

Alkenylsuccinic anhydrides can be prepared by heating alpha olefins (C<sub>10-20</sub>) and maleic anhydride above 190°C. These products are useful in paper sizing and starch products.

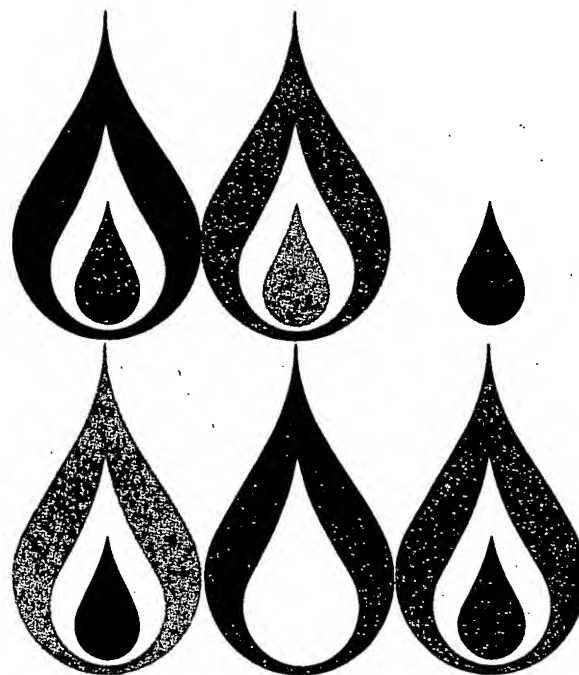
Maleic anhydride may be added to alpha olefins forming copolymers. Laboratory and commercial testing indicate these resins are:

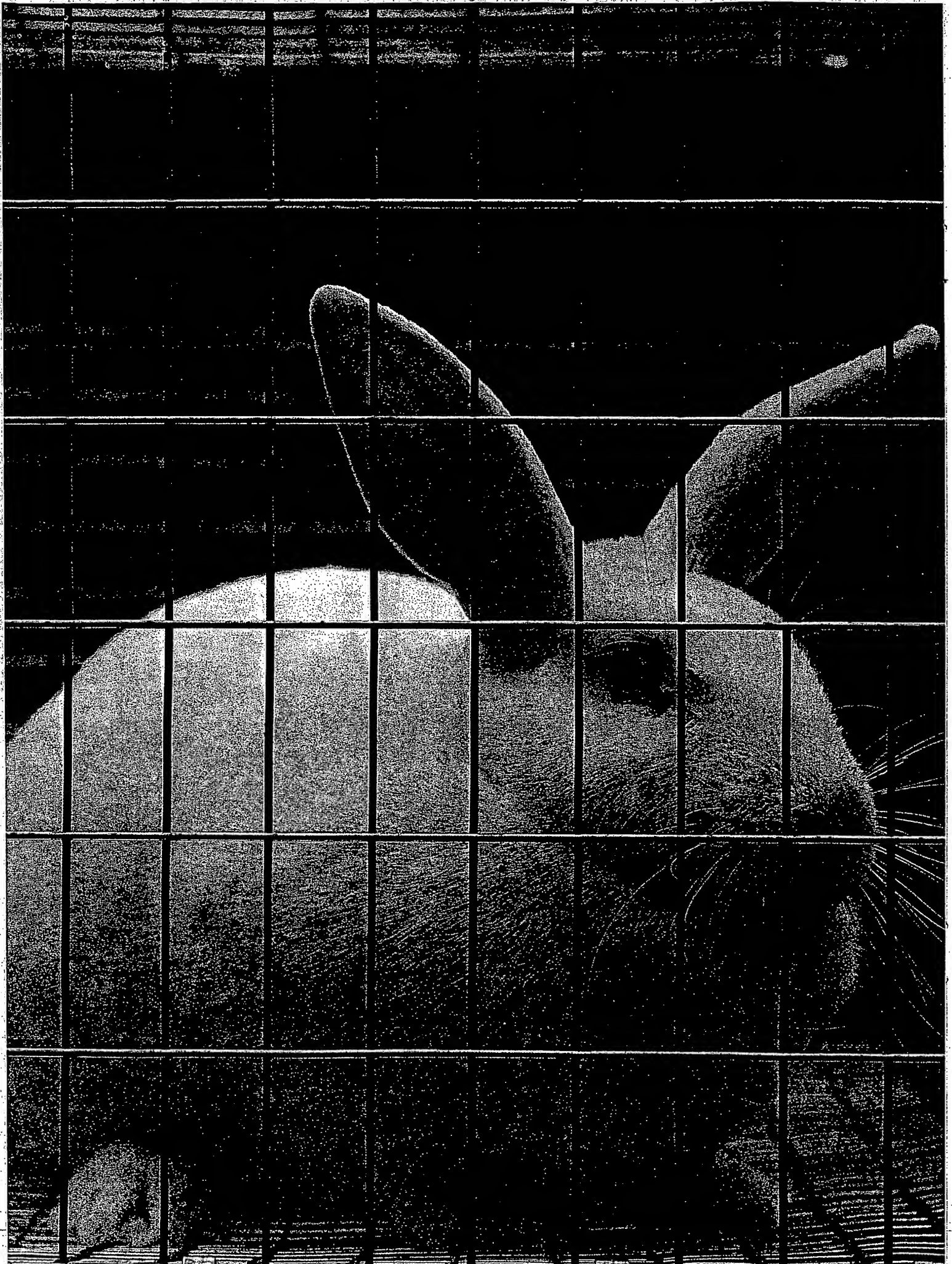
1. effective curing agents for epoxy resins
2. unique thermoset resin compositions in liquid monoepoxides
3. interesting as simple salts for textile sizes and protective colloids
4. excellent leveling resins (as half ester derivatives) in floor polish formulations.

The alpha olefins above C<sub>20</sub> are waxy products and can find uses similar to paraffins. For example, C<sub>30+</sub> improves wax blends for candles, crayons, and coatings. These fractions may also be further reacted to simulate more expensive carnauba or Montan waxes.

Alpha olefins may be converted by metathesis or disproportionation and dimerization reactions to olefins of different chain lengths.

Ketones and esters may be made from alpha olefins. Pyrazines have also been made from alpha olefins.





# V. Toxicology

## Names

The compounds discussed in this brochure are named according to carbon chain length where specific entities are involved. The compounds are:

- C<sub>6</sub> Alpha Olefin (hexene-1) Gulftene-6
- C<sub>10</sub> Alpha Olefin (decene-1) Gulftene-10
- C<sub>16</sub> Alpha Olefin (hexadecene-1) Gulftene-16
- C<sub>12-16</sub> Alpha Olefin Blend

The Gulftene Alpha Olefins chosen above for this toxicological study are considered representative of the product line, allowing for reasonable interpolation with specific blends or compounds not included.

## Physical Properties

Table 2.

	C <sub>6</sub>	C <sub>10</sub>	C <sub>16</sub>	C <sub>12-16</sub>
Physical State	Liquid	Liquid	Liquid	Liquid
Molecular Weight	84	140	224	178
Boiling Point: °F	147	338	539	401-572
Flash Point (TOC) °F	<20	128	>200	195
Vapor Pressure mm Hg @ 75°F	176	1.6	<1	<1

## Toxicity

Threshold Limit Values: None established by ACGIH\*

Gulf suggested Threshold Limit Value:

Vapors— 500 ppm (parts per per million by volume) by analogy with saturated aliphatic hydrocarbons. Higher molecular weight materials should fall short of this concentration due to their lower vapor pressure.

Mists— 5 mg/m<sup>3</sup> by analogy with mineral oil mists.

Animal Toxicity Data: (See Table 3) Animal studies have shown the alpha olefins to have little or no toxic effect except under very severe inhalation conditions. The oral and dermal LD50 values for the tested alpha olefins are in excess of 10gm/kg (non-toxic\*\*); skin and eye irritation are minimal, at most; sensitization has not been demonstrated. Inhalation anesthetic effects were produced when the C<sub>6</sub> olefin vapor concentration approached the LC50 of 32,000 ppm. Light anesthetic effects

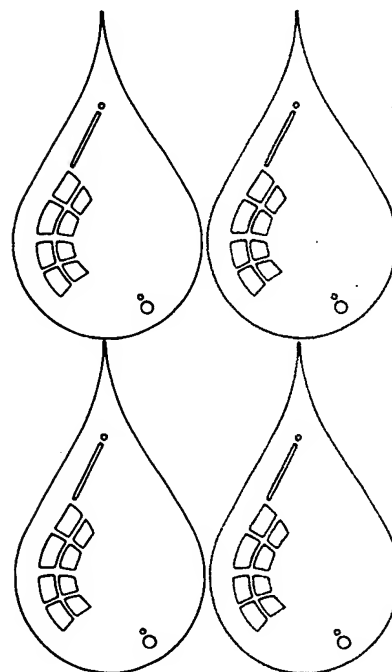
occurred with separate exposures to air saturated with C<sub>10</sub> olefin vapors, C<sub>16</sub> and C<sub>12-16</sub> olefin mists.

Industrial exposures to very high vapor concentrations of the C<sub>6</sub> olefin such as might be produced in an enclosed, unventilated space may induce loss of consciousness or death if exposure is prolonged. Exposure for prolonged period at levels above the suggested Threshold Limit Value for the other olefins might produce giddiness or incoordination similar to that anticipated for the saturated aliphatic hydrocarbons.

## Handling and Personnel Protection

Excessive and prolonged exposures to vapors should be prevented. Local or general exhaust ventilation should be used to prevent accumulation of high vapor concentrations above the recommended TLV. Where adequate engineering controls are not available, a NIOSH certified organic vapor respirator or supplied air breathing apparatus should be used. Vapor concentrations expected to be harmful to health may also constitute a hazard from fire or explosion.

As a matter of good industrial hygiene practice, avoid splashes of the liquid in the eyes or prolonged contamination of the skin. Splashes in the eye should be removed by thorough flushing with water and skin areas should be washed with soap and water. Contaminated clothing should be laundered before reuse.



\*American Conference of Governmental Industrial Hygienists

\*\*Federal Hazardous Substance Act

# Animal Toxicity Data

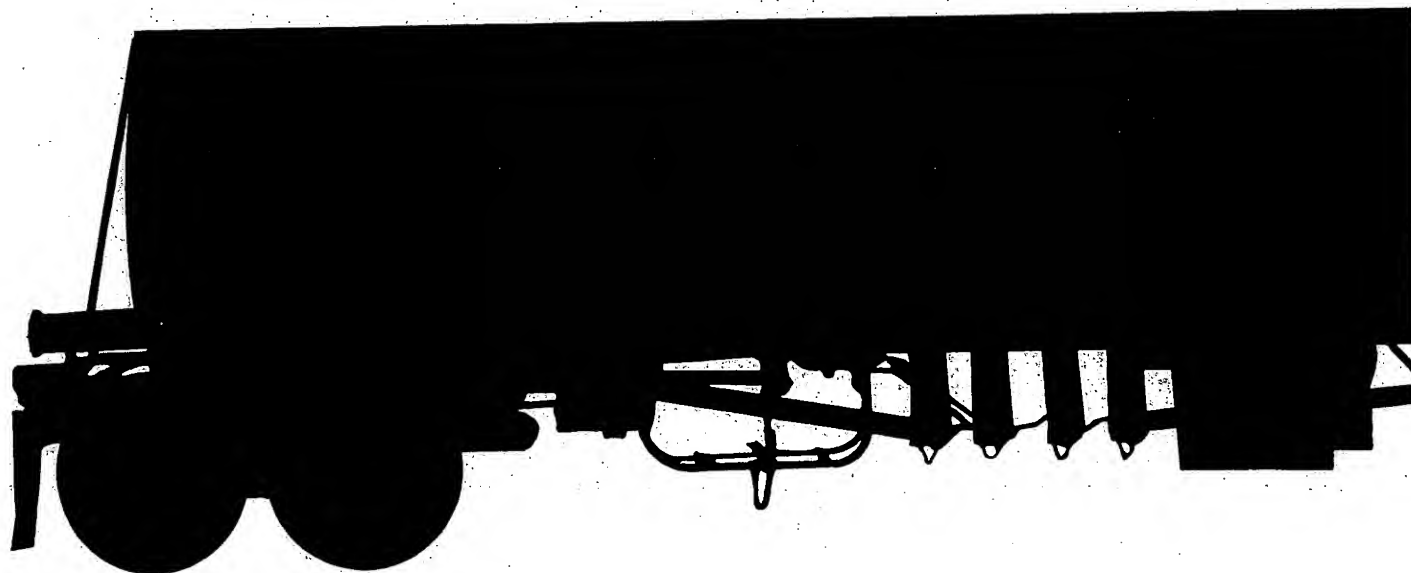
Table 3.

Study Description	C <sub>6</sub>	C <sub>10</sub>
Acute Oral— Rats, LD50 Values Given	>10 gm/kg	>10gm/kg
Acute Dermal— Rabbits, LD50 Values Given	>10 gm/kg	>10 gm/kg
Dermal Irritation— Rabbits, Draize Score Given	1.0	0.9
Eye Irritation— Rabbits, Draize Score Given	24 hr: 1.7 48 hr: 1.3 72 hr: 0.7	0.7 0.3 0.0
Inhalation— Rats, Saturated Concentrations & Results Given	Vapor Exposure: 5 min. @ 161,000 ppm  Mortality: 10/10  Clinical Signs: Tremor, convulsions, death. Some evi- dence of pulmonary irritation.	Vapor Exposure: 1 hr. @ 320 ppm  Mortality: 0/10  Clinical Signs: Sleepy, dazed during exposure. Rapid recov- ery after exposure.
Inhalation— Rats, 4 Hr. Vapor Exposures & Mortality Given	27,600 ppm-0/10 28,600 ppm-2/10 30,500 ppm-5/10 33,200 ppm-7/10 37,000 ppm-8/10 41,200 ppm-10/10 Calculated LC50 (4 hr.)— 32,000 ppm (95% confidence interval of 30,000-34,200 ppm)	
Skin Sensitization— Guinea Pigs. Testing Procedure—Landsteiner Variation. Results Given		

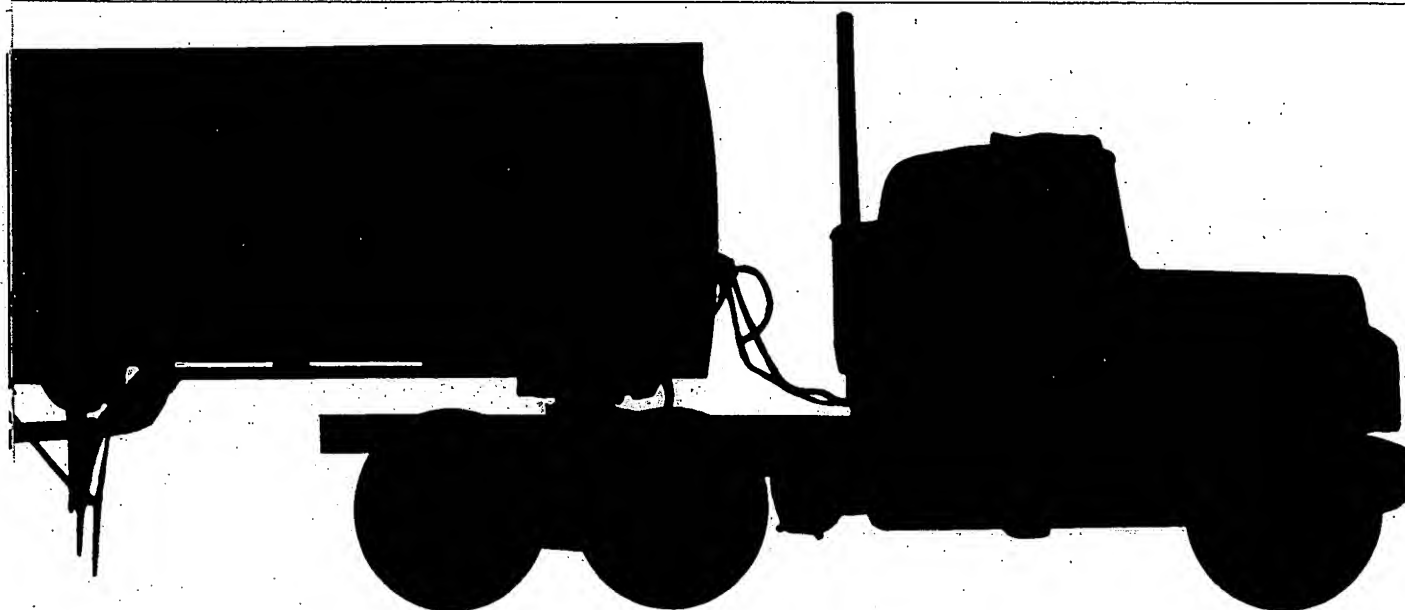
C <sub>16</sub>	C <sub>12-16</sub> Blend	Comments
>10 gm/kg	>10 gm/kg	Transient weight loss after dosing. Not-toxic (FHSA)
>10 gm/kg	>10 gm/kg	No regrowth of hair. Skin dry & scaly for 2 wks. after dosing. Not-toxic (FHSA)
0.6	0.4	Very mild to slight irritation. Not "primary irritants" by FHSA definition.
1.3 0.3 0.0	1.0 0.7 1.3	Transient, slight to mild conjunctival redness, no cornea or iris impairment. Non-irritating by FHSA definitions.
Mist Exposure: 1 hr. @ 8,500 mg/m <sup>3</sup>  Particle Size: <8 microns in diameter.  Clinical Signs: Drowsy, no deaths.	Mist Exposure: 1 hr. @ 9,900 mg/m <sup>3</sup>  Particle Size: <8 microns in diameter.  Clinical Signs: Drowsy, no deaths.	Most severe possible conditions for vapor & mist exposure.
		Progressive light to severe anesthetic effects. All deaths occurred during exposure. Recovery rapid on removal from vapors.
	Test—negative response to challenge application.  Control (chlorodinitrobenzene)— positive response to challenge application.  Control (vehicle)—negative response to challenge application.	Not a dermal sensitizer. No anticipated dermal sensitization to alpha olefins.

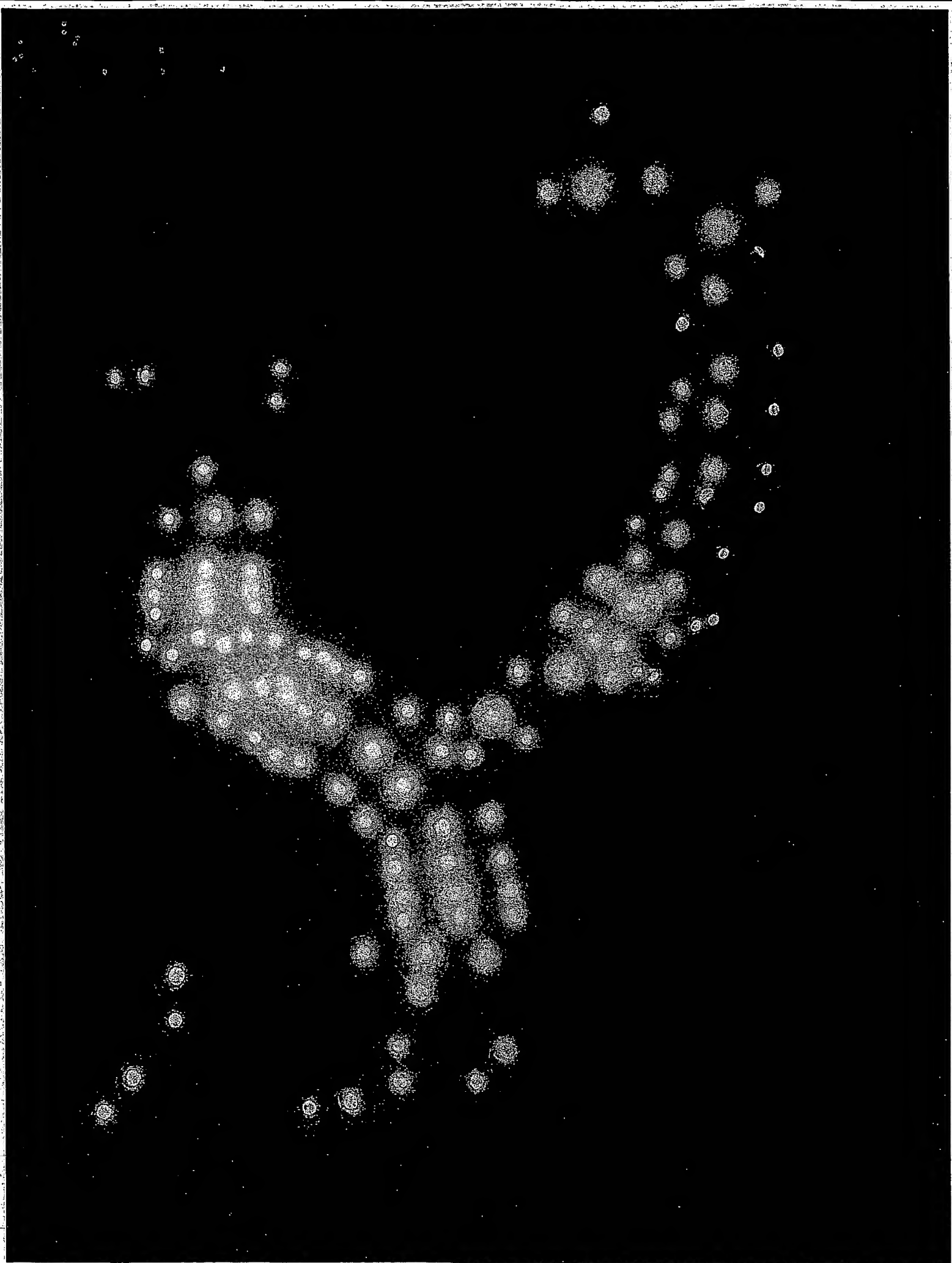
## VI. Handling and Shipping Information

Shipping Data	Gulftene 4 Butene-1	Gulftene 6 Hexene-1	Gulftene 8 Octene-1	Gulftene 10 Decene-1	Gulftene 12 Dodecene-1
Lb./Gal. at 60F	5.008	5.64	6.00	6.21	6.36
Container and Net Weight (lbs.)					
5-Gallon Pail (Epoxy Lined), net weight	Not Available	26	28	30	30
55-Gallon Drum (Epoxy Lined), net weight	Not Available	310	330	342	350
Bill of Lading Commodity Description:					
Pails and Drums	—	Petroleum Naphtha- Flammable Liquid		Petroleum Naphtha	
Tank Truck or Tank Car	Liquified Petroleum	Petroleum Naphtha-		Combustible	
	Gas-flammable Compressed	Flammable Liquid		Liquid N.O.S. Petroleum Naphtha	
	Gas-Butene-1				
Dot Classification	Flammable Compressed Gas	Flammable Liquid		Combustible Liquid N.O.S.	
Railroad Shipping Point	Eldon, Texas				
Railroad Carrier	Southern Pacific				
Truck Location	Cedar Bayou, Texas				



<b>Gulftene 14 Tetradecene</b>	<b>Gulftene 16 Hexadecene</b>	<b>Gulftene 18 Octadecene-1</b>	<b>Gulftene 20 Eicosene-1</b>	<b>Gulftene 20-24 Fraction</b>	<b>Gulftene 24-28 Fraction</b>	<b>Gulftene 30+ Fraction</b>
6.46	6.54	6.60	6.66	6.67	6.83	6.95
31	32	33	33	33	34	34
356	360	363	366	366	375	380
Petroleum Naphtha			Petroleum Wax		Petroleum Wax	
Petroleum Naphtha			Petroleum Wax		Petroleum Wax	
Not Regulated			Not Regulated		Not Regulated	







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Gulftene detergent derivatives lend emolliency to synthetic detergent bars and build foam into shampoos.

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# Gulftene<sup>TM</sup> Alpha Olefin Data

Gulftene<sup>TM</sup> Alpha Olefins

Gulf Oil Chemicals Company

P.O. Box 3766

Houston, Texas 77001

## GULFTENE 4

### BUTENE-1

PRODUCT CHARACTERISTICS	TYPICAL ANALYSES	SALES SPECIFICATIONS
Butene-1: Wt. % Gulf 1028	98.5	min. 98.0
Saturated Hydrocarbons: Wt. % Gulf 1028	1.4	max. 1.8
Cis and Trans Butene-2: Wt. % Gulf 1028	0.1	max. 0.1
Isobutane: Wt. % Gulf 1028	<0.05	max. 0.05
Other Hydrocarbons: Wt. % Gulf 1028	<0.1	max. 0.1
Water: PPM by Wt. Gulf 967	15	max. 15
Acetylenes: PPM Gulf 1138	<1	max. 5
Sulfur: PPM Gulf 834	<1	max. 1



# Gulftene<sup>™</sup> Alpha Olefin Data

Gulftene<sup>™</sup> Alpha Olefins

Gulf Oil Chemicals Company

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## GULFTENE 6

### HEXENE-1

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATION
Specific Gravity, D <sup>a</sup> 1298: 60°/60°F.	0.678	—
Flash, P-M: °F.	bel. 60	—
Color, Saybolt	+30	not darker than +30
Appearance, Gulf 498: 70°-80°F.	passes	clear and free of visible impurities
Water, Gulf 525: PPM	<25	max. 25
n-Alpha Olefins, Gulf 1027: Wt. %	97.0	min. 96.0
Monoolefins, Gulf 1027: Wt. %	98.6	min. 98.5
Vinylidenes, Gulf 1027: Wt. %	1.3	max. 1.75
Olefins Other Than n-Alpha and Vinylidenes, Gulf 1027: Wt. %	0.2	max. 1.0
Saturates, Gulf 1027: Wt. %	1.4	max. 1.5
Carbon No., Gulf 1030: Wt. % C <sub>6</sub>	99.8	min. 99
Below C <sub>4</sub> and Above C <sub>8</sub>	<0.10	max. 0.10
Peroxides as Active Oxygen, Gulf 1151: PPM	<1.0	max. 1.0
Distillation, D <sup>a</sup> 1078		
5% Cond. at: °C.	60	—
95	66	—

<sup>a</sup>ASTM Method

This product can be included in blends within tolerances of  $\pm 5\%$  by weight.



# Gulftene<sup>TM</sup> Alpha Olefin Data

Gulftene<sup>TM</sup> Alpha Olefins

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## GULFTENE 8

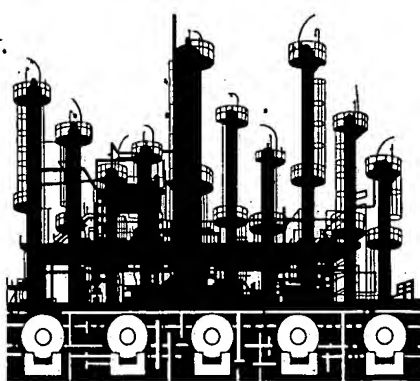
### OCTENE-1

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATION
Specific Gravity, D <sup>a</sup> 1298: 60°/60°F.	0.719	—
Flash, P-M: °F.	bel. 60	—
Color, Saybolt	+30	not darker than +30
Appearance, Gulf 498: 70°-80°F.	passes	clear and free of visible impurities
Water, Gulf 525: Wt. %	0.01	max. 0.02
n-Alpha Olefins, Gulf 1029: Wt. %	96.1	min. 95.5
Monoolefins, Gulf 1029: Wt. %	98.6	min. 98.5
Saturates, Gulf 1029: Wt. %	1.4	max. 1.5
Carbon No., Gulf 1030: Wt. % C <sub>8</sub>	99.7	min. 99
Distillation, D <sup>a</sup> 1078		
5% Cond. at: °C.	118	—
95	128	—

<sup>a</sup>ASTM Method

This product can be included in blends within tolerances of  $\pm 5\%$  by weight.





# Gulftene<sup>™</sup> Alpha Olefin Data

Gulftene<sup>™</sup> Alpha Olefins

Gulf Oil Chemicals Company

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## GULFTENE 10

### DECENE-1

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATION
Specific Gravity, D <sup>a</sup> 1298: 60°/60°F.	0.745	—
Flash, P-M: °F.	120	—
Color, Saybolt	+30	not darker than +30
Appearance, Gulf 498: 70°-80°F.	passes	clear and free of visible impurities
Water, Gulf 525: Wt. %	0.01	max. 0.02
n-Alpha Olefin, Gulf 1026: Wt. %	95.2	min. 94.6
Monoolefins, Gulf 1026: Wt. %	98.6	min. 98.5
Saturates, Gulf 1026: Wt. %	1.4	max. 1.5
Carbon No., Gulf 1030: Wt. % C <sub>10</sub>	99.4	min. 98
Distillation, D <sup>a</sup> 1078		
5% Cond. at: °C.	164	—
95	175	—

<sup>a</sup>ASTM Method

This product can be included in blends within tolerances of  $\pm 5\%$  by weight.



# Gulftene<sup>TM</sup> Alpha Olefin Data

Gulftene<sup>TM</sup> Alpha Olefins

Gulf Oil Chemicals Company

P.O. Box 3766

Houston, Texas 77001

## GULFTENE 12

### DODECENE-1

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATION
Specific Gravity, D <sup>a</sup> 1298: 60°/60°F.	0.763	—
Flash, P-M: °F.	180	—
Color, Saybolt	+30	not darker than +30
Appearance, Gulf 498: 70°-80°F.	passes	clear and free of visible impurities
n-Alpha Olefins, Gulf 1026: Wt. %	94.0	min. 93.6
Monoolefins, Gulf 1026: Wt. %	98.6	min. 98.5
Saturates, Gulf 1026: Wt. %	1.4	max. 1.5
Carbon No., Gulf 1030: Wt. % C <sub>12</sub>	99.3	min. 97
Distillation, D <sup>a</sup> 1078		
5% Cond. at: °C.	205	—
95	220	—

<sup>a</sup>ASTM Method

This product can be included in blends within tolerances of  $\pm 5\%$  by weight.



## Gulftene<sup>TM</sup> Alpha Olefin Data

Gulftene<sup>TM</sup> Alpha Olefins

Gulf Oil Chemicals Company

P.O. Box 3766

Houston, Texas 77001

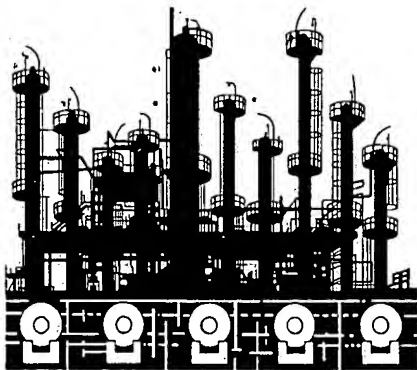
### GULFTENE 14

### TETRADECENE-1

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATION
Specific Gravity, D <sup>a</sup> -1298: 60°/60°F.	0.776	—
Flash, P-M: °F.	225	—
Color, Saybolt	+30	not darker than +30
Appearance, Gulf 498: 70°-80°F.	passes	clear and free of visible impurities
n-Alpha Olefins, Gulf 1026: Wt. %	93.0	min. 92.6
Monoolefins, Gulf 1026: Wt. %	98.6	min. 98.5
Saturates, Gulf 1026: Wt. %	1.4	max. 1.5
Carbon No., Gulf 1030: Wt. % C <sub>14</sub>	98.9	min. 96
Distillation, D <sup>a</sup> -1078		
5% Cond. at: °C.	240	—
95	255	—

<sup>a</sup>ASTM Method.

This product can be included in blends within tolerance of  $\pm 5\%$  by weight.



# Gulftene<sup>TM</sup> Alpha Olefin Data

Gulftene<sup>TM</sup> Alpha Olefins

Gulf Oil Chemicals Company

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Houston, Texas 77001

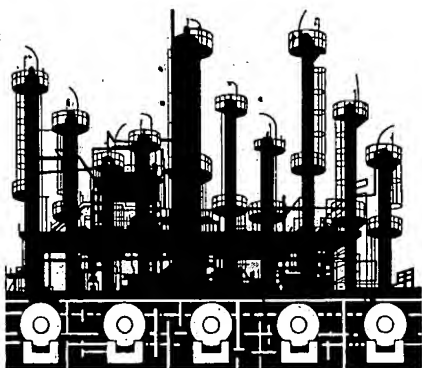
## GULFTENE 16

### HEXADECENE-1

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATION
Specific Gravity, D <sup>a</sup> 1298: 60°/60°F.	0.785	—
Flash, P-M: °F.	270	—
Color, Saybolt	+30	not darker than +30
Appearance, Gulf 498: 70°-80°F.	passes	clear and free of visible impurities
Freezing Point, D <sup>a</sup> 1015: °C.	4	—
n-Alpha Olefins, Gulf 1026: Wt. %	92.0	min. 90.6
Monoolefins, Gulf 1026: Wt. %	98.6	min. 98.5
Saturates, Gulf 1026: Wt. %	1.4	max. 1.5
Carbon No., Gulf 1030: Wt. % C <sub>16</sub>	98.5	min. 95
Distillation, D <sup>a</sup> 1078		
5% Cond. at: °C.	270	—
95	300	—

<sup>a</sup>ASTM Method

This product can be included in blends within tolerances of  $\pm 5\%$  by weight.



# Gulftene<sup>TM</sup> Alpha Olefin Data

Gulftene<sup>TM</sup> Alpha Olefins

Gulf Oil Chemicals Company

P.O. Box 3766

Houston, Texas 77001

## GULFTENE 18

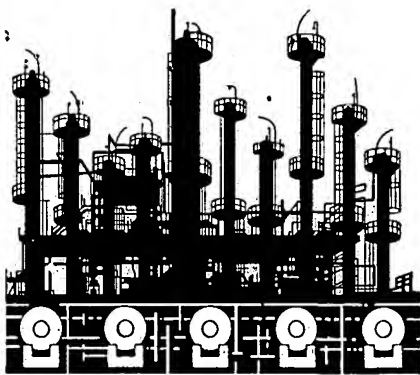
### OCTADECENE-1

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATION
Specific Gravity, D <sup>a</sup> 1298: 60°/60°F.	0.792 <sup>b</sup>	—
Flash, P-M: °F.	310	—
Color, Saybolt	+30	not darker than +30
Appearance, Gulf 498: 70°-80°F.	passes	clear and free of visible impurities
Freezing Point, D <sup>a</sup> 1015: °C.	18	—
n-Alpha Olefins, Gulf 1026: Wt. %	90.8	min. 88.6
Monoolefins, Gulf 1026: Wt. %	98.6	min. 98.5
Saturates, Gulf 1026: Wt. %	1.4	max. 1.5
Carbon No., Gulf 1030: Wt. % C <sub>18</sub>	98.0	min. 94

<sup>a</sup>ASTM Method

<sup>b</sup>Theoretical: Converted from melted liquid gravity to 60°F. by means of ASTM-IP Petroleum Measurement Tables. Determine gravity at least 20°F. above freezing point.

This product can be included in blends within tolerance of  $\pm 5\%$  by weight.



# Gulftene<sup>TM</sup> Alpha Olefin Data

Gulftene<sup>TM</sup> Alpha Olefins

Gulf Oil Chemicals Company

P.O. Box 3766

Houston, Texas 77001

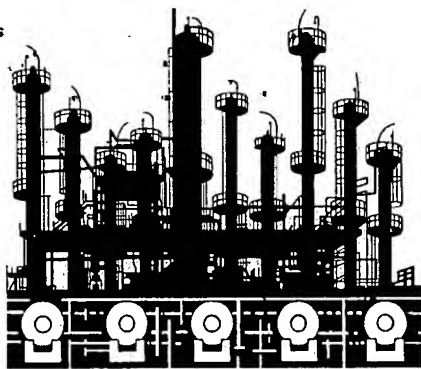
## GULFTENE 20-24

### C<sub>20</sub>-C<sub>24</sub> ALPHA OLEFIN FRACTION

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATIONS
Carbon No., Gulf 1030: Wt. %		
C <sub>18</sub>	1	max. 3
C <sub>20</sub>	49	45-55
C <sub>22</sub>	42	31-47
C <sub>24</sub>	8	max. 15
C <sub>26</sub>	<0.1	max. 1
Gravity, Liquid State: Theor. °API	45.5	—
Sp. Gr., 60°/60°F.: D <sup>a</sup> 1298	0.799 <sup>b</sup>	—
Viscosity, SUV: Sec. 210°F.	33.2	—
Viscosity, Kin.: Cs. 210°F.	2.10	—
Melting Point, D 127: °F.	110	—
Haze Point, °F.	85	—
Flash COC: °F.	375	—
Color, Saybolt	+30	—
Saturates, Gulf Method: Wt. %	1.4	—

<sup>a</sup> ASTM Method

<sup>b</sup> Converted from melted liquid gravity to 60°F. by means of ASTM-IP Petroleum Measurement Tables. Determine gravity at least 20° above freezing point.



# Gulftene<sup>TM</sup> Alpha Olefin Data

Gulftene<sup>TM</sup> Alpha Olefins

Gulf Oil Chemicals Company

P.O. Box 3766

Houston, Texas 77001

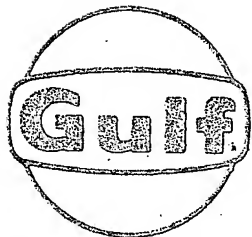
## GULFTENE 24-28

### C<sub>24</sub>-C<sub>28</sub> ALPHA OLEFIN FRACTION

PRODUCT CHARACTERISTICS	TYPICAL VALUE	SALES SPECIFICATIONS
Carbon No., Gulf 1030: Wt. %		
C <sub>22</sub>	1	max. 4
C <sub>24</sub>	30	24-36
C <sub>26</sub>	39	32-42
C <sub>28</sub>	20	15-25
C <sub>30</sub> +	10	max. 17
Gravity, Liquid State: Theor.		
°API	41.3	—
Sp. Gr., 60°/60°F.: D <sup>a</sup> -1298	0.819 <sup>b</sup>	—
Viscosity, SUv; Sec.		
210°F.	34.5	—
Viscosity, Kin.: Cs.		
210°F.	2.50	—
Melting Point, D 127: °F.	145	—
Haze Point, °F.	150	—
Flash, COC: °F.	380	—
Color, Saybolt	+15	—

<sup>a</sup>ASTM Method

<sup>b</sup>Converted from melted liquid gravity to 60°F. by means of ASTM-IP Petroleum Measurement Tables.  
Determine gravity at least 20°F. above freezing point.



**Gulf Petrochemicals**  
**Gulf Oil Chemicals Company**  
P. O. Box 3766 Houston, Texas 77001







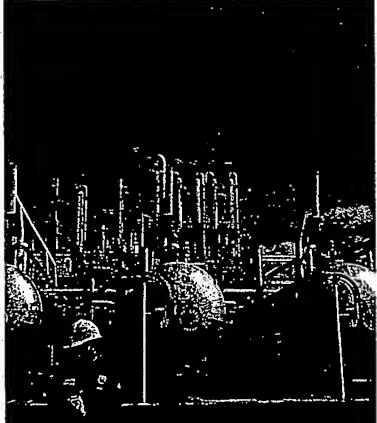
**Chevron**

Olefins and Derivatives

**GULFTENE ALPHA OLEFINS**

**PROVEN DEDICATION TO QUALITY AND  
CUSTOMER SATISFACTION SINCE 1965**

# THE CHEVRON DISTINCTION



More than 700 million pounds or 320,000 metric tonnes of Gulftene alpha olefins are produced annually at Chevron's state-of-the-art Cedar Bayou Petrochemical Complex.

**P**ioneered for commercial use in 1965 by Gulf Oil Chemicals Company, Gulftene® alpha olefins are produced and marketed worldwide by the Olefins and Derivatives Division of Chevron Chemical Company. Since acquiring this product line, we have unrelentingly pursued our mission to be the most reliable supplier of consistent, high-quality normal alpha olefins for the many customers we serve.

## Ongoing Quality Commitment

From technical development and support, manufacturing, sales and marketing, to shipping and customer service, each and every individual at Chevron is committed to premium-quality products, outstanding service and continual improvement of our processes. When you buy Chevron's Gulftene alpha olefins, you buy quality right up to the time they're delivered to your door, whether you are in Antwerp, South Bend, Singapore or Baton Rouge. That's the Chevron distinction.

## Quality Products for Every Application

Chevron Chemical offers a complete line of alpha olefins to meet our customers' specific needs. We produce 11 distinct carbon-length fractions, including: C<sub>4</sub> (1-butene), C<sub>6</sub> (1-hexene), C<sub>8</sub> (1-octene), C<sub>10</sub> (1-decene), C<sub>12</sub> (1-dodecene), C<sub>14</sub> (1-tetradecene), C<sub>16</sub> (1-hexadecene), C<sub>18</sub> (1-octadecene), C<sub>20-24</sub>, C<sub>24-28</sub> and C<sub>30+</sub>. C<sub>4</sub> through C<sub>18</sub> are even-numbered carbon cuts, while fractions C<sub>20-24</sub> and above are olefinic waxes. The alpha olefins C<sub>18</sub> and below can be custom-blended for special applications.

Gulftene alpha olefins, featuring highly accessible terminal double bonds, are ideal materials for manufacturing numerous products. Alpha olefins or their derivatives are used extensively as polyethylene comonomers, plasticizers, synthetic motor oils, lubricants, automotive additives, surfactants, paper size and in a wide range of specialty applications. As major petrochemical building blocks, their use in the development of new chemical products is virtually unlimited.



**Chevron offers the most  
qualified and innovative  
technical support in the  
alpha olefins industry.**

## Reliable Supply of Alpha Olefins

All Chevron Gulftene alpha olefins are produced at our state-of-the-art Cedar Bayou Petrochemical Complex just outside Baytown, Texas, near Houston. From an original output of 120 million pounds annual production, we added another production facility, expanding to a current capacity of more than 700 million pounds or 320,000 metric tonnes annually. Ongoing facility expansion enables us to ensure a dependable supply of consistent, high-quality alpha olefins now and for the future. This is just one of the many ways Chevron is meeting the growing needs of customers worldwide.

Our normal alpha olefin units are equipped with advanced instrumentation and control equipment to maintain production efficiency and uniform quality. A distributed control system (DCS) in tandem with online analyzers for real-time monitoring greatly enhances our units' abilities to maintain product consistency.

Online process sampling verifies carbon number quality and normal alpha olefin content. Quality control and product analysis are performed in our onsite petrochemical laboratory to ensure the quality of our Gulftene products.



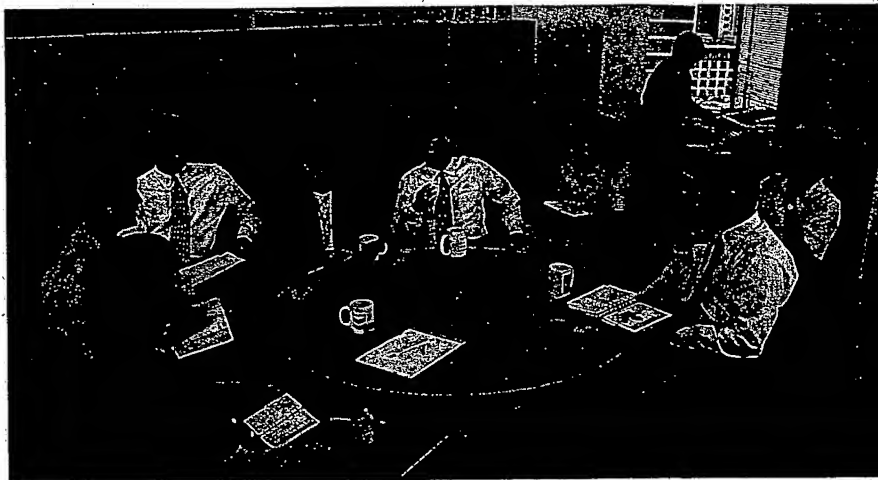
Chevron continues to  
lead the work of Gulf  
chemist, Dr. Herb Fernald,  
who pioneered the  
development of alpha  
olefins in 1952.

## Chevron People Do . . .

When it comes to alpha olefins, Chevron offers a consistently high level of product purity and the widest selection of fractions. However, what really differentiates us is the teamwork, technical expertise, and commitment of every employee to continuous quality improvement and customer service.

Our dedication to supplying consistently high-quality products and services is not something we just talk about. It is a conviction that we practice daily. Our Total Quality Management program is applied to every aspect of our business, as demonstrated in our ISO 9002 certification. Chevron's people have made all this possible.

Highly trained professionals from technical, manufacturing, sales and marketing, customer service and shipping work together to efficiently and innovatively meet the needs of our customers worldwide. We diligently seek out customers' opinions through surveys and direct contact to guide our actions for improving products and services.



**Behind Chevron's  
success as a global  
supplier of alpha  
olefins is a team  
dedicated to serving  
customers' needs.**

Our strategically located offices in Houston, Texas; Voorhees, New Jersey; Geneva, Switzerland; and Singapore are staffed with experienced, technical account managers. These individuals are there to assist you with all your alpha olefins requirements—from the usual to the most challenging requests.

Our respected technical group, based in Kingwood, Texas, works closely with customers to enhance product quality, improve existing olefin and derivative technologies and help develop new applications.

Knowledgeable customer account representatives, supported by a team of distribution account representatives, are available 24 hours a day. They work closely with the other business functions to ensure that our Gulftene products are delivered on time anywhere in the world.

In addition, we use the most advanced business systems available, enabling us to provide the most efficient service possible. Everything from order taking, deliveries and inventory to accounting, forecasting and supplying samples is instantly at our fingertips so we can provide prompt responses to your questions and requests.

## TYPICAL PHYSICAL CHARACTERISTICS

Gulftene alpha olefins, from C<sub>4</sub> to C<sub>30+</sub> carbon lengths, are high-quality intermediates. They are straight-chain hydrocarbons with a double bond in the terminal position. At ambient conditions, C<sub>4</sub> is a gaseous product and C<sub>6</sub> through C<sub>18</sub> are clear, water-white liquids with a distinctive olefinic odor. The C<sub>20+</sub> products are solid at room temperature and have a white, waxy appearance.

TYPICAL PROPERTIES <sup>(1)</sup>	C <sub>4</sub>	C <sub>6</sub>	C <sub>8</sub>	C <sub>10</sub>	C <sub>12</sub>	C <sub>14</sub>	C <sub>16</sub>	C <sub>18</sub>	C <sub>20/24</sub>	C <sub>24/28</sub>	C <sub>30+</sub>
Monolefin, %	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.2	99.4
Alpha Olefin, %	99.6	98.4	97.4	96.4	95.2	94.1	92.3	91.3			
Saturates, %	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.8	0.6
Molecular Weight	56.1	84.2	112.2	140.3	168.3	196.4	224.4	252.5			
Flash, °C, TCC, ASTM D56		7	13	49	77						
Flash, °C, PM, ASTM D93						107	132	154	183	218	252
Freezing Point, °C, ASTM D1015					1	13	4	18			
Melting Point, °C, ASTM D87									36	67	77*
Density at 15.6°C, Lb./Gal.	5.01	5.64	5.99	6.20	6.35	6.46 <sup>(2)</sup>	6.54	6.55 <sup>(2)</sup>	6.41 <sup>(3)</sup>	6.49 <sup>(3)</sup>	6.58 <sup>(4)</sup>
Specific Gravity at 15.6°C/15.6°C	0.602	0.678	0.719	0.745	0.763	0.776	0.785	0.792	0.799	0.819	0.836
Distillation, °C, ASTM D86											
10% Distilled		62.7	120.1	167.0	210.2	246.5	279.8				
90% Distilled		64.0	122.7	171.5	215.4	251.7	285.4				

\*Drop melting point, ASTM D127

(1) More information on each product may be found in the information sheets at the back of this brochure.

(2) At 25°C

(3) At 71°C

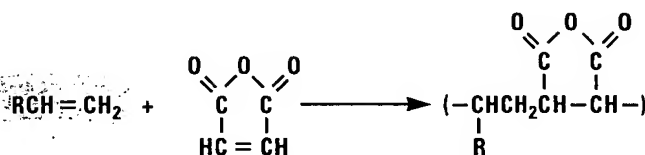
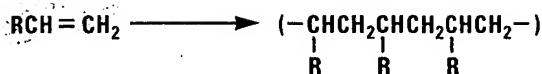
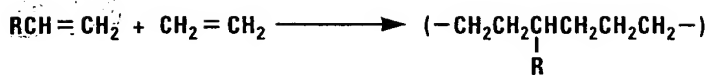
(4) At 85°C

## TYPICAL REACTIONS

### Polymerization

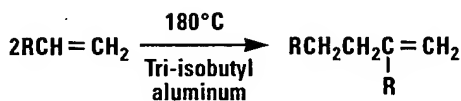
Ethylene and Gulfene alpha olefins can be copolymerized by conventional catalyst systems used to produce high-density and linear low-density polyethylene. Gulfene products can also be homopolymerized with the same catalysts, producing 1-polybutene, for example.

Our alpha olefins can also be copolymerized with maleic anhydride or maleate esters via free radical initiators to produce alternating 1:1 copolymers.



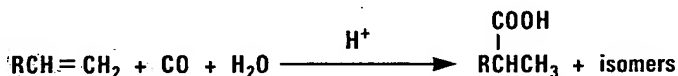
### Oligomerization and Dimerization

Gulfene alpha olefins can be treated with Lewis acids to produce dimers, trimers, tetramers and related compounds. The resultant products are highly branched and consequently have much lower pour points than straight-chained hydrocarbons of the same molecular weight. Dimers with a terminal double bond and an alkyl group on the second carbon of the double bond can also be produced by using an aluminum alkyl catalyst.



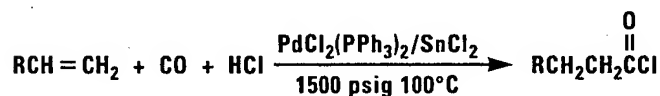
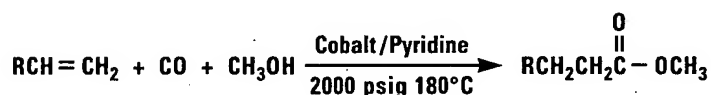
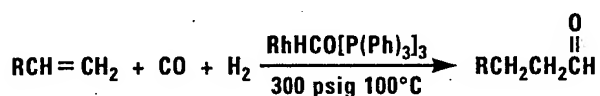
### Koch Reaction

The Koch reaction produces a mixture of branched carboxylic acids from alpha olefins. The reaction proceeds in the absence of a solvent and is applicable to C<sub>6</sub> to C<sub>24</sub> alpha olefins.



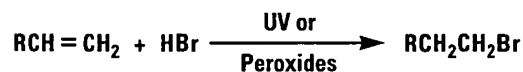
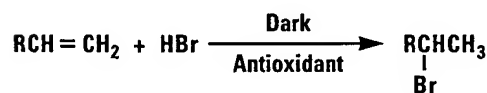


Chevron's intensive research and product application/development focus has resulted in the most extensive line of alpha olefins on the market today.



#### Oxo Chemistry

Chevron alpha olefins will react with carbon monoxide and a variety of nucleophiles to produce aldehydes, alcohols, esters or acid chlorides:



#### Addition of Hydrogen Bromide

Secondary or primary alkyl bromides will result from the reaction of hydrogen bromide with our alpha olefins by Markownikoff or anti-Markownikoff addition.



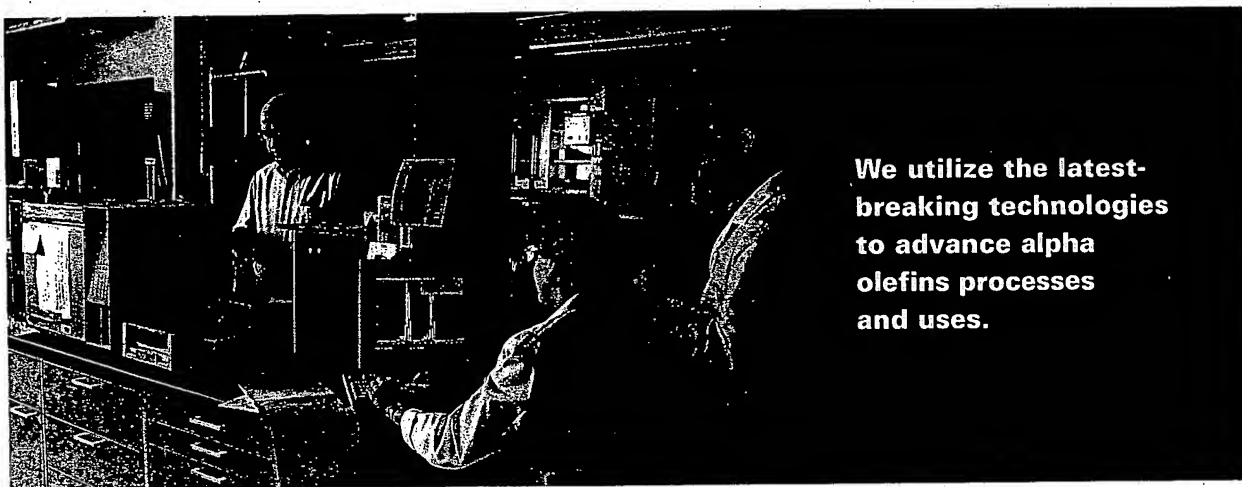
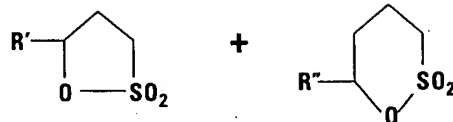
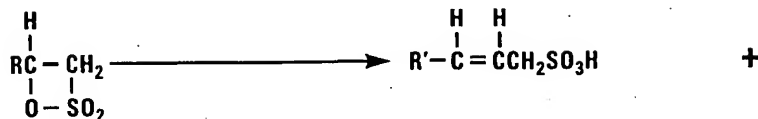
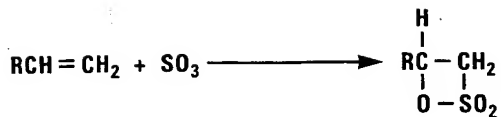
#### Addition of Sodium Bisulfite

Sodium bisulfite can be directly added to Chevron alpha olefins using peroxides or other free radical initiators, producing a sodium alkane sulfonate with the sulfonate group in the terminal position.



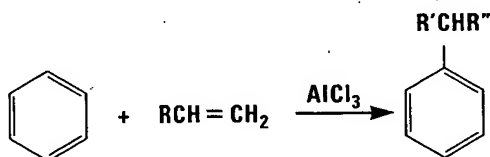
### Addition of Sulfur Trioxide

Sulfur trioxide reacts with alpha olefins in a highly exothermic reaction via a 2 + 2 cyclo addition mechanism to produce a beta sultone as the initial product. The sultone is unstable and rearranges into a mixture of alkene sulfonic acids plus gamma and delta sultones.



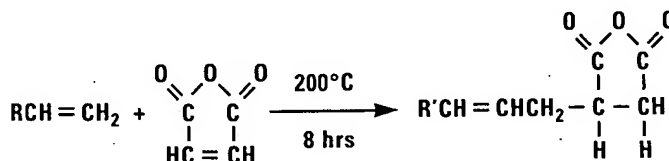
### Alkylation Reactions

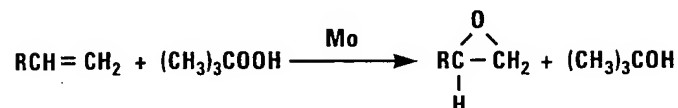
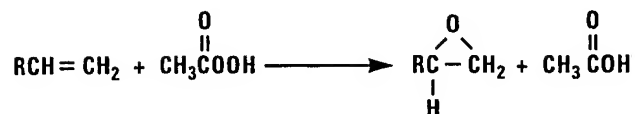
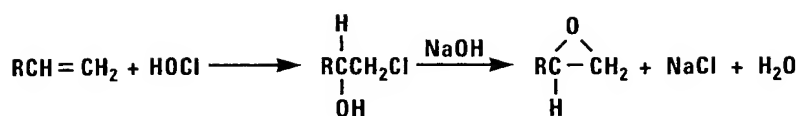
With acid catalysis, alpha olefins readily alkylate aromatic compounds such as benzene and phenol. The products are mixtures of linear alkyl aromatics, ideal for conversion to detergents via sulfonation or ethoxylation.



### Addition of Maleic Anhydride

Alpha olefins and maleic anhydride react to form alkenyl succinic anhydrides (ASA).



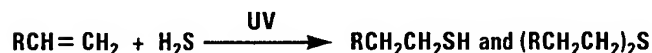
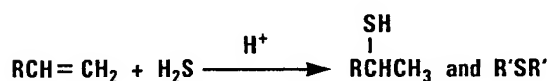


### Epoxidation

Alpha olefins can be converted into 1,2 epoxides by the addition of hypochlorous acid followed by treatment with base, treatment with peracids, or by using *t*-butylhydroperoxide and a molybdenum catalyst.

### Addition of Hydrogen Sulfide

When hydrogen sulfide is added to alpha olefins, mercaptans and sulfides are produced. The relative yields of each can be influenced by reaction conditions and reactant concentrations. In the absence of free radicals, Markownikoff addition will occur. However, the presence of peroxides or UV light will induce anti-Markownikoff addition.



Our dedicated, experienced people are essentially an extension of your company, working closely with you to enhance product quality, improve upon existing technologies and develop new applications.





To ensure consistent product quality, our Gulftene alpha olefins are continually sampled and subjected to rigorous testing by our quality control experts.

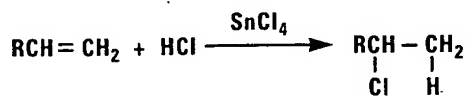
#### Addition of Halogens

Chlorine and bromine both readily add to alpha olefins to form 1,2-dihaloalkanes. Because the reaction is highly exothermic, it should be carried out slowly with cooling.



#### Addition of Hydrogen Chloride

Using a weak Lewis acid catalyst, hydrogen chloride reacts with alpha olefins to form secondary alkyl chlorides. The reaction is a typical Markownikoff addition. Hydrogen chloride and alpha olefins will not react in an anti-Markownikoff manner because the H-Cl bond strength is too great.




## TYPICAL APPLICATIONS

High-quality Gulftene alpha olefins are used in a myriad of commercial products, including polymers, synthetic fluids, surfactants, additives and specialty chemicals.

The terminal double bonds of Gulftene alpha olefins react readily with a wide variety of chemicals (see Typical Reactions, pages 6 through 10). Alpha olefins can be used to synthesize any derivative requiring an even-numbered, straight carbon chain.

TYPICAL APPLICATIONS	C <sub>4</sub>	C <sub>6</sub>	C <sub>8</sub>	C <sub>10</sub>	C <sub>12</sub>	C <sub>14</sub>	C <sub>16</sub>	C <sub>18</sub>	C <sub>20/24</sub>	C <sub>24/28</sub>	C <sub>30+</sub>
<b>Polymers</b>											
Polyethylene Comonomers	■		■								
Homopolymers	■										
Copolymers							■		■		
<b>Surfactants</b>											
AOS							■				
Detergent Alcohols			■		■						
Alkyl Aromatics			■		■		■		■		
ADMA					■		■				
<b>Synthetic Fluids</b>											
Polyalphaolefins			■	■	■						
Polyol Esters			■								
Lube Oil Additives							■		■		
<b>Additives</b>											
Plasticizer Alcohols			■								
ASA			■		■		■				
PVC Lubricants											■
<b>Specialty Chemicals</b>											
Epoxides	■		■		■		■		■		
Mercaptans	■		■		■						
Metal Working							■				
Halogenated Olefins				■	■		■		■		■
Alkyl Silanes			■		■		■				■
Metal Alkyls	■	■	■		■						



Because we care deeply about the quality and consistency of our products, no detail is overlooked. Chevron is passionate about satisfying customer needs and our technical support is world-renowned.

## POLYMERS

### Homopolymers and Copolymers Other Than Polyethylene

Certain Gulftene alpha olefins can be used to prepare homopolymers and copolymers other than polyethylene. Gulftene 4 can be polymerized to 1-polybutene (PB), a homopolymer that is ideal for many engineering applications because of its excellent long-term mechanical properties.

PB is extremely creep resistant and behaves similarly to a crosslinked plastic. It features a unique combination of unusually high tensile strength and good tear properties. PB shows no signs of cracking, crazing or fracturing when stressed below its short-time failure stress value for long periods of time. In addition, its tear strength increases rapidly as the tear rate escalates. PB's benefits broaden the commercial applications for polymers.

Gulftenes 6, 8, 10, 16, 18, 20-24 and 24-28 are used for the production of copolymers. Using peresters as initiators, copolymers of maleic anhydride and alpha olefins can be formed.



#### Copolymers

Alkyl Dimethyl Amines  
Alkenyl Succinic  
Anhydrides

#### Alkyl Aromatics

Alpha Olefin Sulfonates  
Synthetic Lubricants



Maleic Anhydride  
Copolymers  
Primary Mercaptans  
PVC Lubricants and  
Additives  
Epoxides

Oxo-Alcohols  
Carbon Paper-  
Printing Inks  
Dihalides-Polyhalides  
Metal Alkyls  
Alkyl Silanes

Our extensive line of  
Gulftene alpha olefins is  
used in many commercial  
applications, including  
polymers, synthetic fluids,  
surfactants, additives and  
specialty chemicals.

The maleic copolymer made from Gulftene 18 is a Chevron product known as PA-18, which has been used successfully as a release agent in tapes and paper templates for PVC curtains, and in water-resistant sunscreen formulas.

The copolymers produced from other Gulftene alpha olefin fractions are normally converted to acid amides, half esters or diesters for use as lube-oil additives and pour-point depressants. They are also effective curing agents for epoxy resins and act as unique thermoset resin compositions in liquid monoepoxides. In addition, Gulftenes 6, 8 and 10 have been co- and terpolymerized with vinyl acetate and vinyl chloride.



## Polyethylene Copolymers

Chevron Gulftenes 4, 6 and 8 have become increasingly important as comonomers with ethylene for the production of high strength and high stress-crack resistant, high-density polyethylene (HDPE) resins.

HDPE is principally used for the manufacture of household and industrial chemical bottles, oil bottles, food containers, grocery sacks, merchandise bags and pipe.

High-density polyethylene possesses high flex stiffness (flexural modulus) but low environmental stress cracking resistance (ESCR). Lowering the melt index (high melt viscosity) can help to alleviate the low ESCR, but the processibility of the polymer suffers due to lower flow rates. The addition of Chevron Gulftene 4, 6 or 8 as a comonomer increases the melt index, thereby improving the flow properties and greatly increasing the ESCR.

In addition, HDPE polymers made with Gulftene 6 as a comonomer have much higher ESCR than those made with 1-butene. For a given polymerization process, at a polymer density of 0.950 g/cc and melt index ranges of 0.2 to 0.3 g/10 minutes, 1-butene copolymers had ESCR values of 50 to 310 hours and 1-hexene copolymers exhibited ESCR values of 800 to more than 1,000 hours. Copolymerizing with Gulftene 8 rather than 1-hexene produces polymers with even better ESCR values.

Similarly, linear low-density polyethylene (LLDPE) produced with Chevron alpha olefins is strong and has excellent stress crack resistance, making it ideal for many film applications, as well as for the production of overcaps or lids for food containers.

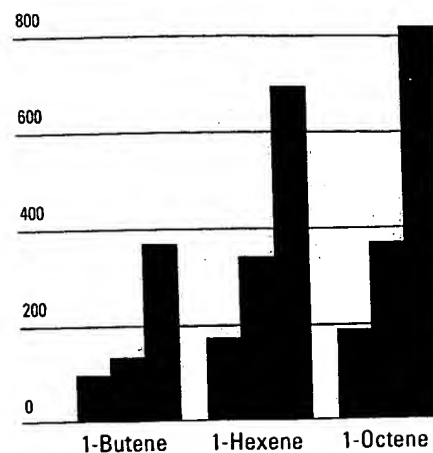
In the past, only high-pressure or conventional low-density polyethylenes (LDPEs) were used for applications requiring flexibility. However, many of these applications now utilize linear low-density polyethylene.

LLDPE is made by incorporating a higher level of comonomer, either 1-butene, 1-hexene or 1-octene, to reduce the density of linear polyethylene relative to HDPE. Yet, LLDPE provides significantly greater stiffness and much higher ESCR values than LDPE. Because the melt index of the LLDPE can be raised to values much higher than that of LDPE (while maintaining equivalent or superior physical properties), processing cycle times can be reduced. In addition, if processing times are satisfactory, products made with LLDPE can be downgauged to save on raw material costs.

Because of its outstanding strength and tear resistance, linear low-density polyethylene is used in virtually all film applications. Film made entirely from LLDPE or from blends of LLDPE and LDPE is far stronger than that made only from LDPE. The type of comonomer used in manufacturing LLDPE affects the material's strength. Film made from LLDPE using Gulftene 8 is stronger and more tear resistant than that made with Gulftene 4 as the comonomer.

For the greatest possible strength and tear resistance, the density can be reduced below that of LLDPE and LDPE through copolymerization with lower alpha olefins to produce very low-density polyethylene (VLDPE). VLDPE has a higher heat-seal temperature than LDPE, yet provides equivalent seal strength.

Effects of Comonomer on Film Properties



1.0 Mil Film Strength, Grams

■ Impact  
■ MD Tear  
■ TD Tear

## SURFACTANTS

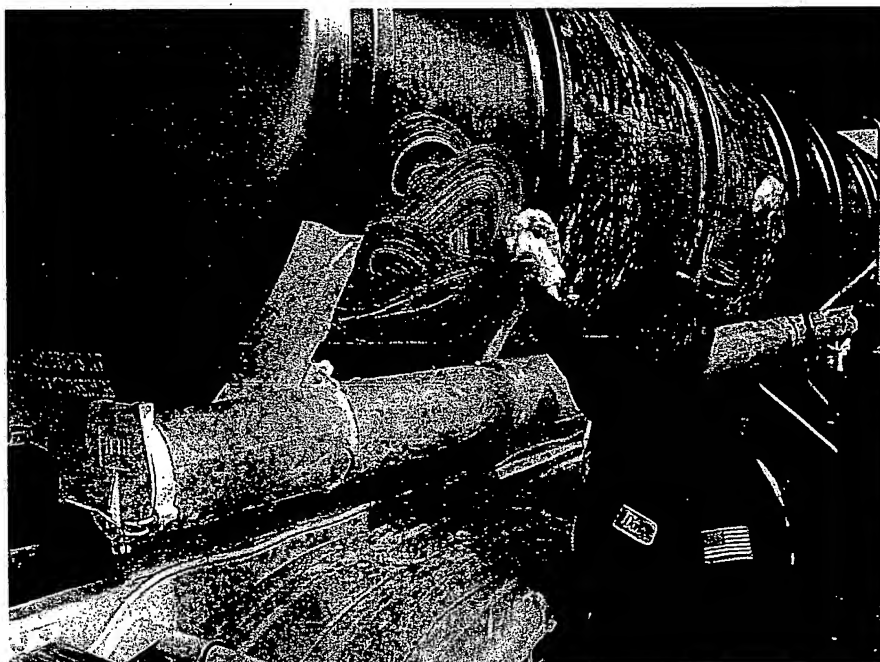
### Alpha Olefin Sulfonate (AOS)

Gulftenes are excellent intermediates for producing alpha olefin sulfonate (AOS) surfactants. These surfactants provide outstanding detergency, high compatibility with hard water, and good wetting and foaming properties. AOS is free of skin irritants and sensitizers, and it biodegrades rapidly. It is used in high-quality shampoos, light-duty liquid detergents, bubble baths, and heavy-duty liquid and powder detergents. It is also used in emulsion polymerization.  $C_{14-16}$  AOS blends are frequently used in liquid hand soaps.

To make AOS, alpha olefins are first sulfonated in a continuous thin film reactor to produce a mixture of alkene sulfonic acids and sultones (cyclic sulfonate esters). The mixture is neutralized with aqueous sodium hydroxide, then hydrolyzed at elevated temperatures to convert the remaining sultones to alkene sulfonates and hydroxy sulfonates. This results in an aqueous solution of alpha olefin sulfonate. (If a solid, anhydrous product is desired, it can be easily obtained by neutralizing and hydrolyzing the solution in isopropanol instead of water.)

### Detergent Alcohols

Gulftenes are easily converted to primary alcohols via oxo chemistry. By reaction with ethylene oxide, the alcohols form a variety of nonionic ethoxylates, which may themselves serve as surfactants or be further derivatized. Anionic alkyl ether sulfates can be derived from the sulfation of the ethoxylates. These are widely used in the cosmetics and toiletries industries. Alternatively, the alcohols may be directly sulfated to produce alkyl sulfates.





## Linear Alkyl Benzene Sulfonates

Gulftenes react with benzene via Lewis acid catalysis to form linear alkyl benzenes (LABs). Sulfonation and subsequent neutralization of LAB result in linear alkyl benzene sulfonates, which are commonly used in dishwashing liquids, laundry detergents, all-purpose cleaners and lube-oil additives. Similarly, phenol or naphthalene will react with olefins, producing other types of detergents and wetting agents upon sulfonation/neutralization.

## Amine Derivatives

Gulftenes are also suitable for manufacturing alkyl dimethyl amines (ADMAs), which are precursors to a number of surface-active derivatives. Amine oxides produced via hydrogen peroxide oxidation of ADMAs are excellent foam boosters and are typically used in shampoos, bubble baths and dishwashing detergents.

Quaternary ammonium halides or "Quats," which result from reaction of ADMAs with alkyl or benzyl halides, are highly effective biocides and anti-static agents. Betaines, which are mild, amphoteric surfactants, feature good foam boosting and stabilizing properties. They are readily derived from ADMAs by reaction with sodium chloroacetate.

## Alkane Sulfonates

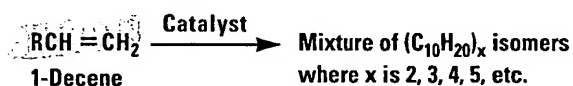
Sodium bisulfite will react with Gulftenes via a free-radical mechanism to produce alkane sulfonates. Alkane sulfonates with chain lengths of  $C_{12}$  or higher have limited water solubility, suggesting their application in synthetic detergent bars. Shorter alkane sulfonates like  $C_8$ , however, are hydrotropic.

## SYNTHETIC FLUIDS

### Polyalphaolefins

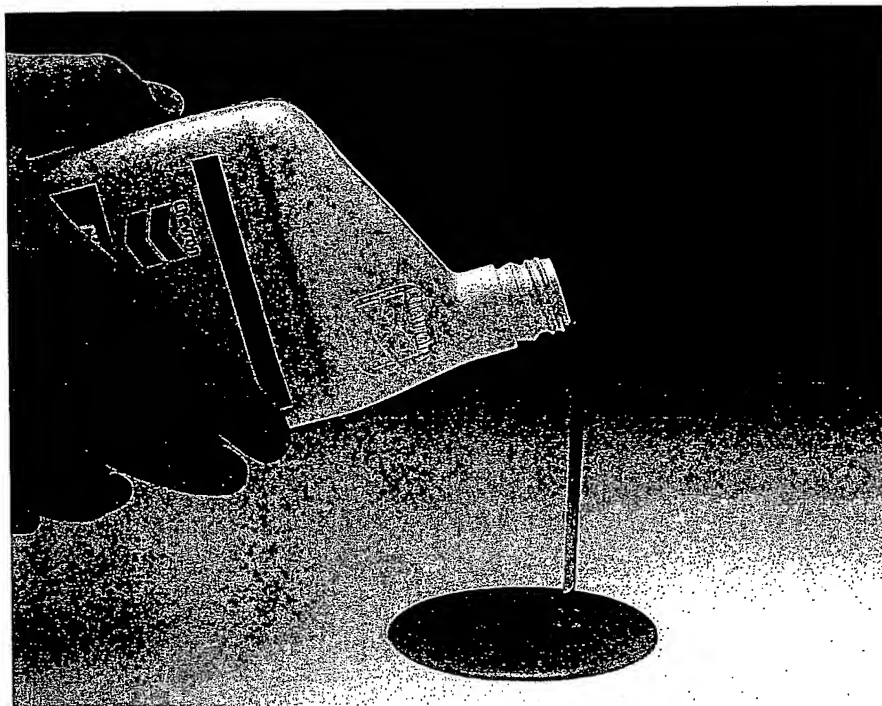
Synthetic base fluids for high-performance lubricants and functional fluids can be prepared by oligomerizing Gulfene alpha olefins, particularly Gulfene 10. The resulting oligomers, consisting of dimers, trimers, tetramers and so on, are typically hydrogenated and then formulated with appropriate additives.

Polyalphaolefin (PAO) fluids such as Chevron's Synfluid® PAO are miscible with mineral oils and most other synthetic base fluids, and are compatible with most commonly used coatings, plastics, elastomers and other conventional materials. Their excellent low temperature properties, high viscosity index and low volatility result in superior automotive, industrial and aerospace lubricants offering greater efficiencies, longer service life and improved economics relative to mineral oil.



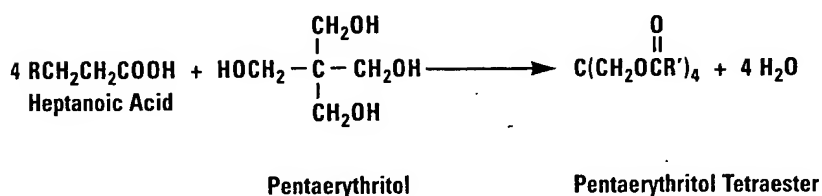
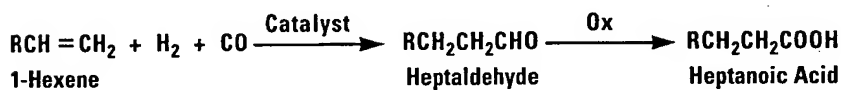
PAO AND MINERAL OIL COMPARISON	PAO4	100N Oil*	PAO6	200N Oil*
Viscosity, cSt @ 100°C	3.9	4.1	5.9	6.3
Viscosity, cSt @ 40°C	16.9	20.2	30.5	40.8
Viscosity, cSt @ -40°C	2420	Solid	7500	Solid
Viscosity Index	127	98	135	162
Pour Point, °C	-73	-12	-68	-6
Noack Volatility, Wt. %	13	30	6	19

\*Solvent Refined Mineral Base Oil



## Polyol Esters

Gulftene alpha olefins yield odd-numbered acids upon hydroformylation followed by oxidation. Polyol esters are then prepared by reacting the acids with polyols such as pentaerythritol. A key feature of these esters is their outstanding tolerance of a wide range of temperatures. This is one reason that they are used as the base fluids for jet engine lubricants and refrigeration compressor oils for the new HFC-134a chlorine-free refrigerants.



## Alkyl Aromatics

Phenol or benzene can be alkylated with Gulftene alpha olefins to produce phenates or dialkyl benzenes. Phenates (alkyl phenol salts) are used successfully for lubricant additives. Dialkylbenzenes perform well as synthetic fluids and lubricants.

## **ADDITIVES**

### **Plasticizer Alcohols**

C<sub>8</sub> through C<sub>10</sub> alpha olefins are used to produce primary C<sub>9</sub> through C<sub>11</sub> plasticizer alcohols via hydroformylation or oxo chemistries. The phthalate plasticizers produced from these alcohols gave superior properties to those made from 2-ethyl 1-hexanol. The same chemistry is used to produce C<sub>13</sub> to C<sub>15</sub> synthetic detergent alcohols from C<sub>12</sub> and C<sub>14</sub> alpha olefins.

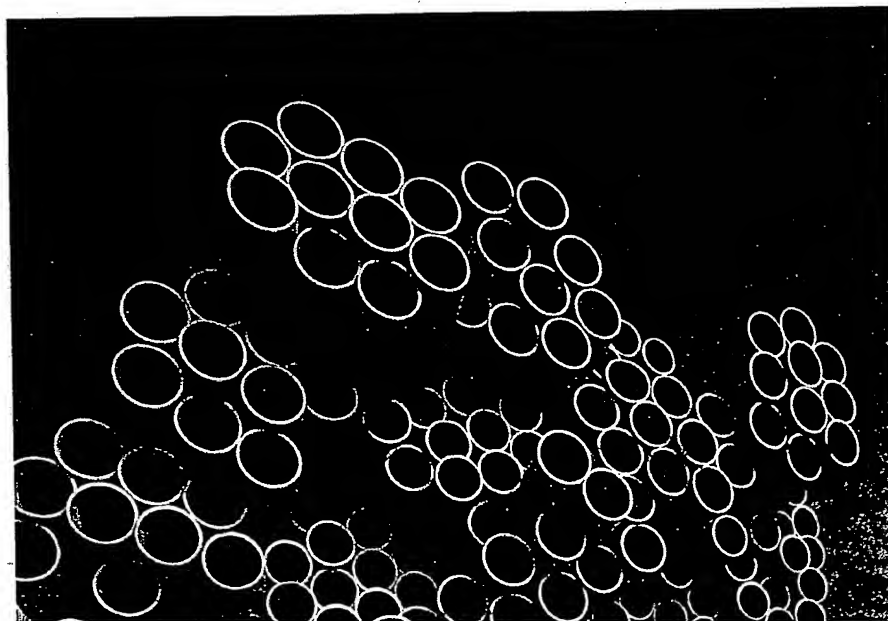
### **Alkenyl Succinic Anhydrides**

Alkenyl succinic anhydrides (ASAs) are prepared by heating alpha olefins and maleic anhydride to approximately 200°C. Some ASAs are used as dispersants in lube oils and automatic transmission fluids, and as pour-point depressants in lube and crude oils. Others are converted to acid amides, half esters and diesters. One of the largest applications for ASA is as the paper sizing agent in alkaline media. For this use, Gulftenes 16 or 18 are isomerized to a thermodynamic distribution of internal olefins, which are then reacted with maleic anhydride to produce the desired liquid ASA.

### **Polyvinylchloride Lubricants and Stabilizers**

Heat and pressure are applied during the extrusion of polyvinylchloride (PVC) as it moves through the die. Lubricants (waxes) are compounded into the PVC to ensure proper lubrication in the extruder and to control fusion of the PVC compound. Gulftene 30+ is the preferred lubricant for this application.

During the extrusion process, PVC often begins to decompose. Various materials are used to retard this degradation, including dibutyl or dioctyl tin oxides, and/or dioctyl tin mercaptides. These compounds are made using tin (IV) chloride and the corresponding aluminum alkyls, which in turn are derived from alpha olefins. The mercaptans used to make the tin mercaptides are usually made from alpha olefins.



## SPECIALTY CHEMICALS

### Epoxides

Treatment of alpha olefins with peracids forms epoxides, which find use as modifiers for epoxy resins. Epoxides may also serve as polyether ingredients in polyurethanes. Almost all carbon number fractions of Chevron alpha olefins find some application in the epoxide market.

### Halogenated Alpha Olefins

Chlorinated Gulftene 20-24 ( $C_{20-24}$  alpha olefin) is appropriate for use as a secondary plasticizer in PVC formulations. This 40% chlorinated alpha olefin derivative was evaluated in comparison with Imperial Chemical Industries (ICI) Cereclor 42 (42% chlorinated paraffin) and Conoco H-35 (alkyl-aryl hydrocarbon). The evaluation of the mechanical properties of these formulations shows that the chlorinated Gulftene alpha olefin blend is equivalent in plasticizing efficiency to the two other secondary plasticizers, providing adequate heat stability and volatility properties. It, as well as polychlorinated  $C_{12}$ ,  $C_{14}$  and  $C_{16}$ , also performs well as a stable, high-pressure additive in metalworking fluids.

### Additional Applications

Gulftene alpha olefins can be used in many other applications, including the production of mercaptans, ketones, esters, pyrazines and other compounds, and as substitutes for paraffin and other waxes.

When hydrogen sulfide is added to alpha olefins under the proper conditions, mercaptans are formed. These mercaptans have been used successfully in rubber additives, ore flotation and specialty chemicals applications.

Alpha olefins may be converted to internal olefins of higher chain lengths by metathesis or disproportionation and dimerization reactions.

Trialkylphosphines and trialkylphosphine oxides, silylhydrocarbons, alkyl silanes and some organometallic compounds are produced commercially from alpha olefins for a wide variety of end products.

Derivatives of Gulftene alpha olefins above  $C_{20}$  find uses in lube oils, transmission fluids, and as pour-point depressants in lube and crude oil. These wax fractions may also be chemically modified to simulate more expensive carnauba or Montan waxes used to make polishes and candles.

## SHIPPING AND HANDLING

### Efficient and Reliable Transportation

Chevron Chemical maintains an extensive distribution system to ensure that our products will get to you on the date that we have committed. Our Gulftene alpha olefins are transported in bulk shipments via tank cars or tank trucks. Gulftenes 6 through 30+, with the exception of custom blends, are also available in 55-gallon, steel, epoxy-lined, nonreturnable drums and five-gallon pails. Sample quantities are typically shipped in one gallon cans.

Long before ISO certification became the earmark of quality-commitment, Chevron Chemical adopted the Deming Philosophy, which we have applied to every aspect of our business.



European customers have the option of 1.0- and 1.1-cubic meter totes. Customized blends of two or more fractions, accurate to  $\pm 2$  wt%, are available in tank truck or tank car quantities. Inhibitors to help prevent the formation of peroxides can be added to any of our Gulftene alpha olefins upon request.

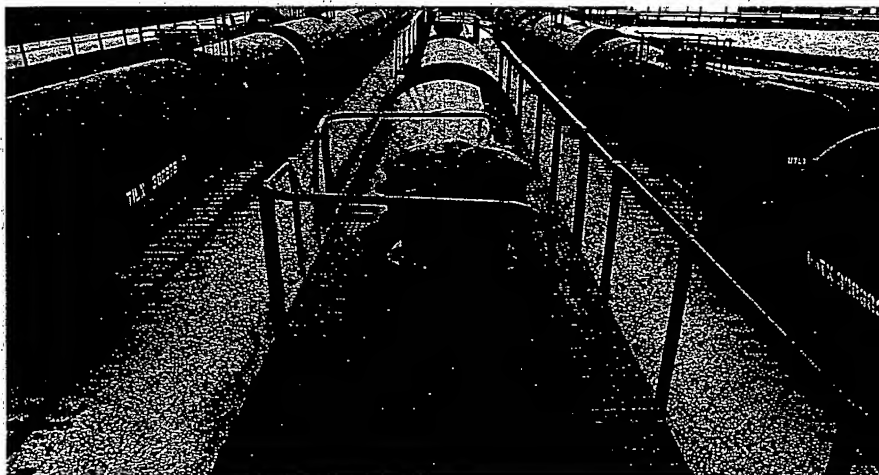
Export shipments in containers and isotanks are made from the Cedar Bayou plant. Products shipped by marine barge and vessel are loaded out of Stolthaven Terminal facilities located on the Houston Ship Channel. These facilities were specially designed and constructed with miles of dedicated piping to prevent contamination.

Utilizing our fleet of tank trucks helps us deliver our products to you on time with no shipping delays.



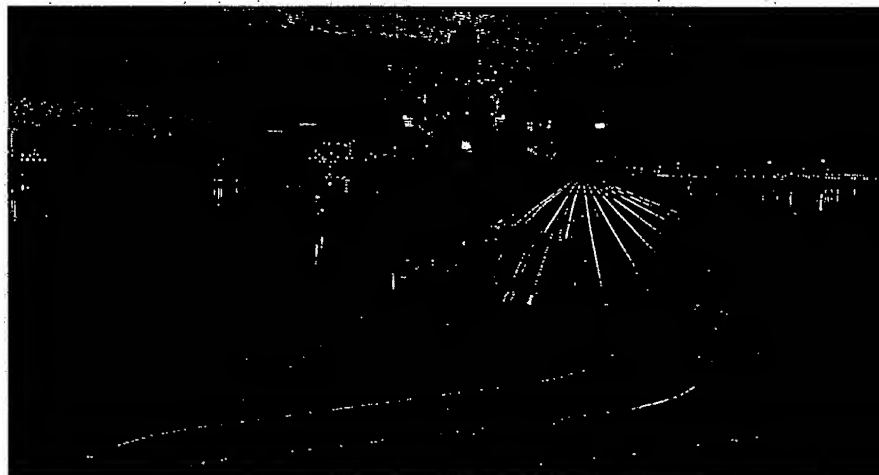
## Responsible Handling

Although Gulftene alpha olefins pose little environmental, health and safety risks, Chevron is committed to the Responsible Care® initiative and to safely providing a quality product. This is demonstrated by the considerable efforts made to ensure the integrity and purity of every shipment, and the precautions we take to protect people and the environment from accidental releases.



**We provide our customers and other handlers with the information they need to safely transport, store, use and dispose of our products.**

Gulftene alpha olefins are stored under nitrogen blankets. To prevent the formation of peroxides and minimize the escape of vapors, our storage tanks and loading facilities for the lower fractions, located at Cedar Bayou, the Stolthaven Terminal and the Antwerp Terminal, feature totally closed systems.



**Chevron storage and loading facilities are specially designed as totally closed systems to minimize accidental release of vapors into the environment.**

Responsible Care is a shared responsibility. Please do your part and carefully review the most current Material Safety Data Sheet (MSDS) on any fraction before you use it.

## TOXICOLOGY

The following toxicology information is based on selected Gulftene alpha olefins as well as other alpha olefins toxicity data. The fractions chosen for toxicological studies were considered representative of the product line, allowing for reasonable interpolation for blends not included.

PHYSICAL PROPERTIES	C <sub>6</sub>	C <sub>10</sub>	C <sub>16</sub>	C <sub>12-16</sub>
Physical State	Liquid	Liquid	Liquid	Liquid
Molecular Weight	84	140	224	73
Boiling Point, °F	147	381	539	401-572
Flash Point (TOC) °F	<20	128	>200	195
Vapor Pressure, mm Hg at 75°F	176	16	<1	5

### Toxicity

Studies have shown that Gulftene alpha olefins have little or no toxic effect on animals except in very severe inhalation conditions. Based on the high oral and dermal LD50 values, these materials are considered to be relatively nontoxic. They produce minimal skin and eye irritation, and are not skin sensitizers. Laboratory exposures to very high airborne concentrations of C<sub>6</sub>-C<sub>16</sub> alpha olefin vapors or mists produced central nervous system effects including anesthesia.

Although not all products have been tested in genetic toxicity assays, the available data indicate alpha olefins are not mutagenic.

Except for one study on one species of rainbow trout, ecotoxicity studies conducted with a wide range of products have shown little potential for toxicity to aquatic organisms.





**We work closely with  
our customers and  
others to make certain  
our products are  
handled safely and  
responsibly.**

### **Handling and Personal Protection**

Chevron is committed to Product Stewardship and Responsible Care. We endeavor to provide sufficient information for the safe use and handling of all our products. It is important to safeguard against excessive and prolonged exposures to alpha olefin vapors and mists. Unsafe vapor concentrations may not only be harmful to workers' health, they may also constitute fire or explosion hazards.

No Threshold Limit Values® (TLVs) for these materials have been established by the American Conference of Governmental Industrial Hygienists (ACGIH).

Adequate local or general exhaust ventilation should be used to prevent the accumulation of high vapor concentrations. National Institute for Occupational Safety and Health (NIOSH)-certified organic vapor respirators or supplied air breathing apparatus should be used in the absence of reliable detection and warning devices.

Good, industrial hygiene practices should always be followed. Avoid contact of alpha olefins with eyes and skin. Splashes in the eye should be treated by thoroughly flushing with water. Contaminated skin areas should be carefully washed with soap and water, and contaminated clothing should be laundered before reuse.

If you want to improve an existing product using alpha olefins or develop a new one, put Chevron Chemical's unbeatable, global team to work for you.

Call (800) 231-3260 or (713) 754-2451 for assistance today!

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Facsimile: (011-65) 235-2524



# GULFTENE® 4 1-BUTENE



**Chevron**  
Chemical

CHARACTERISTIC	METHOD	SPECIFICATION
Carbon Number, wt. % C <sub>4</sub> min.	GLC	99.8
n-Alpha Olefin, wt. % min.	GLC	99.0
cis and trans 2-Butene, wt. % max.	GLC	0.3
Paraffin, wt. % max.	GLC	0.3
Water, ppm by wt., max.	DuPont 5200	10
Oxygen, ppm by wt., max.	ASTM D 2504	5
Carbon Monoxide, ppm by wt., max.	ASTM D 2504-1	2
Carbon Dioxide, ppm by wt., max.	ASTM D 2504-1	2
Chloride, ppm by wt., max.	ASTM D 4929	1
Sulfur, ppm by wt., max.	ASTM D 3120	1

ADDITIONAL INFORMATION	METHOD	TYPICAL VALUE
Specific Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	0.602
Density, lb./gal., 60°F		5.01

While the information and suggestions contained herein are based upon Chevron Chemical's extensive experience, there is no warranty of any kind, express or implied, relating to them. They are offered solely for your consideration, investigation and validation. Because the products are used under varying conditions and may be reacted with various hazardous and toxic chemicals over which Chevron Chemical has no control, Chevron Chemical does not guarantee the results of usage nor assume any liability connected therewith.

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# GULFTENE® 6 1-HEXENE



**Chevron**  
Chemical

CHARACTERISTIC	METHOD	SPECIFICATION
Carbon Number, wt. % C <sub>6</sub> min.	GLC	99.0
n-Alpha Olefin, wt. % min.	GLC	98.2
Vinylidene, wt. % max.	GLC	1.3
cis and trans 2-Hexene, wt. % max.	GLC	0.3
Paraffin, wt. % max.	GLC	0.3
Water, ppm by wt., max.	ASTM E 1064	25
Carbonyls, ppm by wt., max.	ASTM E 411	2.0
Peroxide, ppm by wt., max.	SM 80-17	1.0
Color, Saybolt	ASTM D 156	+30
Appearance	ASTM D 4176	Clear & Bright

ADDITIONAL INFORMATION	METHOD	TYPICAL VALUE
API Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	77.4
Specific Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	0.677
Density, lb./gal., 60°F		5.64
Flash Point, TCC, °F (°C)	ASTM D 56	20.0 (-6.67)
Autoignition Temp., °F (°C)	ASTM E 659	500 (260)

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# GULFTENE® 8 1-OCTENE



**Chevron**  
Chemical

CHARACTERISTIC	METHOD	SPECIFICATION
Carbon Number, wt. % C <sub>8</sub> min.	GLC	99.0
n-Alpha Olefin, wt. % min.	GLC	97.0
Vinylidene, wt. % max.	GLC	2.2
cis and trans 2-Octene, wt. % max.	GLC	0.3
Paraffin, wt. % max.	GLC	0.3
Water, ppm by wt., max.	ASTM E 1064	50
Carbonyls, ppm by wt., max.	ASTM E 411	2
Peroxide, ppm by wt., max.	SM 80-17	1.0
Color, Saybolt	ASTM D 156	+30
Appearance	ASTM D 4176	Clear & Bright

ADDITIONAL INFORMATION	METHOD	TYPICAL VALUE
API Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	65.2
Specific Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	0.719
Density, lb./gal., 60°F		6.00
Flash Point, TCC, °F (°C)	ASTM D 56	55 (12.8)
Autoignition Temp., °F (°C)	ASTM E 659	430 (211)

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# GULFTENE® 10 1-DECENE



CHARACTERISTIC	METHOD	SPECIFICATION
Carbon Number, wt. % C <sub>10</sub> min.	GLC	98.5
n-Alpha Olefin, wt. % min.	GLC	95.8
Vinylidene, wt. % max.	GLC	3.6
cis & trans 2-Decene, wt. % max.	GLC	0.3
Paraffin, wt. % max.	GLC	0.3
Water, ppm by wt., max.	ASTM E 1064	100
Color, Saybolt	ASTM D 156	+30
Appearance	ASTM D 4176	Clear & Bright

ADDITIONAL INFORMATION	METHOD	TYPICAL VALUE
API Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	58.5
Specific Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	0.745
Density, lb./gal., 60°F		6.21
Flash Point, TCC, °F (°C)	ASTM D 56	120 (48.9)
Autoignition Temp., °F (°C)	ASTM E 659	410 (210)

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# GULFTENE® 12 1-DODECENE



CHARACTERISTIC	METHOD	SPECIFICATION
Carbon Number, wt. % C <sub>12</sub> min.	GLC	98.0
n-Alpha Olefin, wt. % min.	GLC	94.6
Vinylidene, wt. % max.	GLC	4.2
cis and trans 2-Dodecene, wt. % max.	GLC	0.3
Paraffin, wt. % max.	GLC	0.3
Water, ppm by wt., max.	ASTM E 1064	100
Color, Saybolt	ASTM D 156	+30
Appearance	ASTM D 4176	Clear & Bright

ADDITIONAL INFORMATION	METHOD	TYPICAL VALUE
API Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	54.1
Specific Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	0.762
Density, lb./gal., 60°F		6.36
Pour Point, °F (°C)	ASTM D 97	-33 (-36.1)
Freezing Point, °F (°C)	ASTM D 1015	-31 (-35.0)
Flash Point, TCC, °F (°C)	ASTM D 56	171 (77.2)
Autoignition Temp., °F (°C)	ASTM E 659	399 (204)

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# GULFTENE® 14

## 1-TETRADECENE



**Chevron**  
Chemical

CHARACTERISTIC	METHOD	SPECIFICATION
Carbon Number, wt. % C <sub>14</sub> min.	GLC	98.0
n-Alpha Olefin, wt. % min.	GLC	93.4
Vinylidene, wt. % max.	GLC	5.4
cis & trans 2-Tetradecene, wt. % max.	GLC	0.3
Paraffin, wt. % max.	GLC	0.3
Water, ppm by wt., max.	ASTM E 1064	100
Color, Saybolt	ASTM D 156	+30
Appearance	ASTM D 4176	Clear & Bright

ADDITIONAL INFORMATION	METHOD	TYPICAL VALUE
API Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	51.0
Specific Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	0.775
Density, lb./gal., 60°F		6.46
Pour Point, °F (°C)	ASTM D 97	10 (-12.2)
Freezing Point, °F (°C)	ASTM D 1015	9 (-12.8)
Flash Point, PM, °F (°C)	ASTM D 93	225 (107)

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# GULFTENE® 16 1-HEXADECENE



**Chevron**  
Chemical

CHARACTERISTIC	METHOD	SPECIFICATION
Carbon Number, wt. % C <sub>16</sub> min.	GLC	97.5
n-Alpha Olefin, wt. % min.	GLC	92.2
Vinylidene, wt. % max.	GLC	6.5
cis & trans 2-Hexadecene, wt. % max.	GLC	0.3
Paraffin, wt. % max.	GLC	0.3
Water, ppm by wt., max.	ASTM E 1064	100
Color, Saybolt	ASTM D 156	+30
Appearance	ASTM D 4176	Clear & Bright

ADDITIONAL INFORMATION	METHOD	TYPICAL VALUE
API Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	48.8
Specific Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	0.785
Density, lb./gal., 60°F		6.54
Pour Point, °F (°C)	ASTM D 97	45 (7.2)
Freezing Point, °F (°C)	ASTM D 1015	39 (3.9)
Flash Point, PM, °F (°C)	ASTM D 93	270 (132)

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# GULFTENE® 18 1-OCTADECENE



CHARACTERISTIC	METHOD	SPECIFICATION
Carbon Number, wt. % C <sub>18</sub> min.	GLC	97.0
n-Alpha Olefin, wt. % min.	GLC	90.6
Vinylidene, wt. % max.	GLC	7.9
cis and trans 2-Octadecene, wt. % max.	GLC	0.3
Paraffin, wt. % max.	GLC	0.3
Water, ppm by wt., max.	ASTM E 1064	100
Color, Saybolt	ASTM D 156	+30
Appearance	ASTM D 4176	Clear & Bright

ADDITIONAL INFORMATION	METHOD	TYPICAL VALUE
API Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	46.9
Specific Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	0.793
Density, lb./gal., 60°F		6.60
Pour Point, °F (°C)	ASTM D 97	65 (18.3)
Freezing Point, °F (°C)	ASTM D 1015	64 (17.8)
Flash Point, PM, °F (°C)	ASTM D 93	310 (154)

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# GULFTENE® 20-24

## ALPHA OLEFIN FRACTION



CHARACTERISTIC	METHOD	SPECIFICATION
Carbon Number, wt. %		
C <sub>18</sub> , max.	GLC	3.0
C <sub>20</sub> , min. - max.	GLC	45-60
C <sub>22</sub> , min. - max.	GLC	30-50
C <sub>24</sub> , max.	GLC	15
C <sub>26</sub> , max.	GLC	1.0
Color, Saybolt	ASTM D 156	+30
Appearance	ASTM D 4176	Clear & Bright

ADDITIONAL INFORMATION	METHOD	TYPICAL VALUE
n-Alpha Olefin, wt. %	GLC	89.3
Vinylidene, wt. %	GLC	8.0
cis and trans 2-Olefin, wt. %	GLC	0.3
Paraffin, wt. %	GLC	0.3
API Gravity 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	0.799
Specific Gravity (Solid) 60°F/60°F (15.6°C/15.6°C)	ASTM D 70 (Modified)	0.856
Specific Gravity (Liquid) 160°F/60°F (71°C/15.6°C)	SM 350-4	0.770
Density, lb./gal., 60°F		6.67
Melting Point, °F (°C)	ASTM D 87	96 (35.6)
Flash Point, PM, °F (°C)	ASTM D 93	362 (183)
Viscosity, 99°C (210°F)		
- Kinematic, cSt	ASTM D 445	2.1
- Saybolt, SUS	ASTM D 2161	33
Penetration, 77°F	ASTM D 1321	150
Distillation, °F (°C)	ASTM D 1160/5mm	
IBP		146 (63.3)
5%		358 (181.1)
95%		400 (204.4)
EP		410 (210.0)
Color, APHA	APHA	<5

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# GULFTENE® 24-28 ALPHA OLEFIN FRACTION



CHARACTERISTIC	METHOD	SPECIFICATION
Carbon Number, wt. %		
C <sub>20</sub> , max.	GLC	1.8
C <sub>22</sub> , max.	GLC	4.0
C <sub>24-28</sub> , min.	GLC	76.0
C <sub>30+</sub> , max.	GLC	20.0
Color, Saybolt	ASTM D 156	+25
Appearance	ASTM D 4176	Clear & Bright

ADDITIONAL INFORMATION	METHOD	TYPICAL VALUE
n-Alpha Olefin, wt. %	NMR	50
Vinylidene, wt. %	NMR	40
cis and trans 2-Olefin, wt. %	NMR	10
Paraffin, wt. %	Calculated	0.8
API Gravity 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	0.819
Specific Gravity (Solid) 60°F/60°F (15.6°C/15.6°C)	ASTM D 70 (Modified)	0.891
Specific Gravity (Liquid) 160°F/60°F (71°C/15.6°C)	SM 350-4	0.780
Density, lb./gal., 60°F		6.83
Congealing Point, °F (°C)	ASTM D 938	126 (52.2)
Drop Melt Point, °F (°C)	ASTM D 127	154 (67.8)
Flash Point, PM, °F (°C)	ASTM D 93	425 (218)
Viscosity, 99°C (210°F)		
- Kinematic, cSt	ASTM D 445	2.5
- Saybolt, SUS	ASTM D 2161	35
Penetration, .10 mm, 77°F (25°C)	ASTM D 1321	95
Distillation, °F (°C)	ASTM D 1160/5mm	
IBP		190 (87.8)
5%		436 (224.4)
95%		582 (305.6)
EP		608 (320.0), Residue 3%

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# GULFTENE® 30+ ALPHA OLEFIN FRACTION



CHARACTERISTIC	METHOD	SPECIFICATION
Carbon Number, wt. %		
C <sub>22</sub> , max.	GLC	1.0
C <sub>24-28</sub> , max.	GLC	26.0
C <sub>30+</sub> , min.	GLC	72.0
Color, Saybolt, min.	ASTM D 156	0
Appearance	ASTM D 4176	Clear & Bright
Drop Melt Point, °F (°C) min.	ASTM D 127	164 (73.3)
Viscosity, Kinematic, cSt, 99°C (210°F) max.	ASTM D 445	10.0

ADDITIONAL INFORMATION	METHOD	TYPICAL VALUE
n-Alpha Olefin, wt. %	NMR	55
Vinylidenes, wt. %	NMR	40
Olefins, other than n-Alpha and Vinylidenes, wt. %	NMR	5
Paraffin, wt. %	Calculated	0.6
API Gravity, 60°F/60°F (15.6°C/15.6°C)	ASTM D 287	0.836
Specific Gravity (Solid), 60°F/60°F (15.6°C/15.6°C)	ASTM D 70 (Modified)	0.919
Specific Gravity (Liquid), 185°F/60°F (85°C/15.6°C)	SM 350-4	0.790
Density, lb./gal., 60°F		6.95
Congealing Point, °F (°C)	ASTM D 938	155 (68.3)
Flash Point, PM, °F (°C)	ASTM D 93	485 (252)
Viscosity, Saybolt, SUS	ASTM D 2161	52
Penetration, .10 mm	ASTM D 1321	
@ 77°F		13
@ 100°F		24
@ 110°F		34
Distillation, °F (°C)	ASTM D 1160/5mm	
IBP		204 (95.6)
5%		461 (238.3)
95%		643 (339.4)
EP		693 (367.2)

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# **Appendix B**

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[Home](#) / [Products](#) / LUR, ISOBAM

## Chemicals and Resins

**LIR**, Liquid isoprene rubber**ISOBAM**, Isobutylene polymer

Kuraray produces a number of special synthetic resins using isoprene and isobutylene, one of which is LIR. A liquid synthetic rubber, LIR is used as a reactive plasticizer in rubber, and in inorganic-solvent-based adhesives. **ISOBAM**, a copolymer of isobutylene and maleic anhydride, is used as an adhesive.

**Applications**

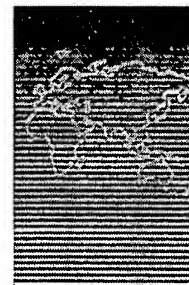
- reactive plasticizer (tires, rollers, etc.)
- adhesive -modifiers -inorganic binder
- waterproofing, water retention, desiccators, insulation

**Company** : [Elastomer Division](#) (Chemicals Company)

**Products**

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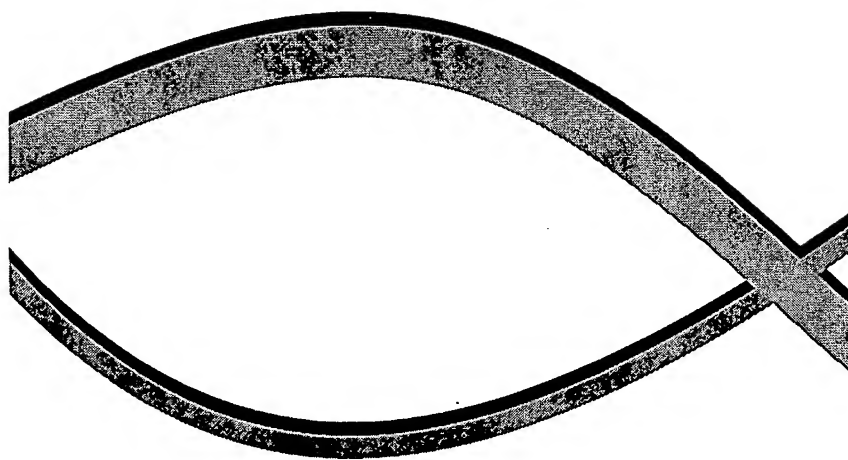
[Kuraray Poval, Mowiol](#) | [Kuraray Poval film](#) | [Exceval](#)  
[Ethylene-vinyl acetate copolymer emulsion](#) | [Mowital](#) | [Eval](#) | [New EVOH barrier resin](#)  
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WATER SOLUBLE POLYMER

**ISOBA M**





ISOBAM is the trade name of an alternative copolymer of isobutylene and maleic anhydride developed by KURARAY using their POVAL® (polyvinyl alcohol) technology.

ISOBAM is an alkali water soluble polymer with outstanding characteristics which have never been acquired by conventional water soluble polymers such as polyvinyl alcohol and cellulose derivatives.

ISOBAM is a white powder in appearance. It is generally used as a water soluble polymer reacting with sodium hydroxide, ammonia and amine.

Various useful reactants are obtained by the reaction of ISOBAM with alcohol, amine and epoxy compounds. These can be applied to resins and plastics.

## ■ Applications

- Adhesives
  - SBR emulsion type
  - Polyvinyl acetate type
- Protective colloids
  - Vinyl acetate
  - Acetal monomer



## “ISOBAM” is

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### ■ Applications

- **Adhesives**
  - SBR emulsion type
  - Polyvinyl acetate type
- **Protective colloids**
  - Vinyl acetate
  - Acryloyl monomer
  - Vinyl chloride
  - Micro-capsule for pressure sensitive paper
- **Binders**
  - Binder for ceramic powder
  - Binder for solid catalyst
- **Metal processing oils**
  - Lubricant for forging
  - Hardening agent for steel
- **Super absorbent polymers**
  - Chemical pocket heater
  - Sealing materials
- **Dispersants**
  - Water-reducing agent for cement
  - Scale inhibitor
  - Dispersing agent for pesticide
  - Water soluble paint
- **Coating for papers**
  - Coating agent for thermal paper
- **Plastic modifications**

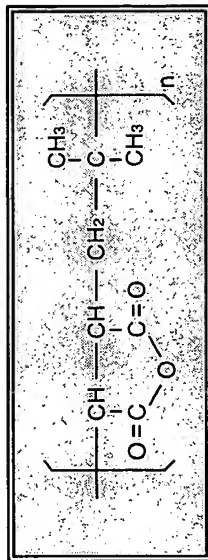
## Physical properties of “ISOBAM”

	Molecular weight *	Appearance	Grading distribution	Density (g/cm <sup>3</sup> )	Melting point	Packed specific gravity (g/cm <sup>3</sup> )	Volatile portion (%)
ISOBAM-500	5,500 ~ 6,500	Powder	—	1.3	None	0.4 ~ 0.7	≤ 5
ISOBAM-04	55,000 ~ 65,000	Powder	12 ~ 200 mesh ≥ 88%	1.3	None	0.3 ~ 0.5	≤ 4
ISOBAM-06	80,000 ~ 90,000	Powder	12 ~ 200 mesh ≥ 88%	1.3	None	0.3 ~ 0.5	≤ 4
ISOBAM-10	160,000 ~ 170,000	Powder	12 ~ 200 mesh ≥ 88%	1.3	None	0.3 ~ 0.5	≤ 4
ISOBAM-18	300,000 ~ 350,000	Powder	12 ~ 200 mesh ≥ 88%	1.3	None	0.3 ~ 0.5	≤ 4
ISOBAM-104	55,000 ~ 65,000	Powder	12 ~ 200 mesh ≥ 88%	1.3	None	0.3 ~ 0.5	—
ISOBAM-110	160,000 ~ 170,000	Powder	12 ~ 200 mesh ≥ 88%	1.3	None	0.3 ~ 0.5	—
ISOBAM-304	55,000 ~ 65,000	Powder	12 ~ 200 mesh ≥ 88%	1.3	None	0.3 ~ 0.5	—
ISOBAM-306	80,000 ~ 90,000	Powder	12 ~ 200 mesh ≥ 88%	1.3	None	0.3 ~ 0.5	—
KI-GEL	∞	Powder	20 mesh ≥ 95%	1.3	None	0.6 ~ 0.9	—

\* Weight- average molecular weight

X

## Standard type of "ISOBAM"

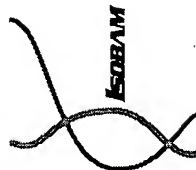


CAS NO. 26426-80-2  
TSCA Registered

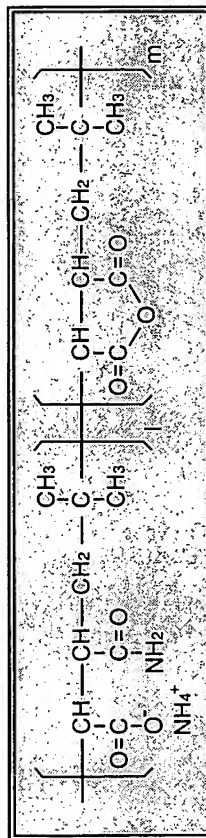
Differing from conventional water soluble polymers, ISOBAM is used by reacting with alkali.

These alkali solutions can be easily modulated from low viscosity to high viscosity and from acidity to alkalinity.

Standard type of ISOBAM is used as binders with excellent heat resistance, and



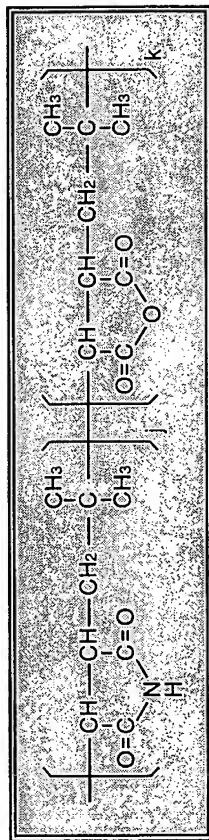
## Amide-ammonium salt type of "ISOBAM"



CAS.NO. 52032-17-4  
TSCA Under making application to TSCA

ISOBAM

## Imide type of "ISOBAM"



CAS NO. 89360-06-5  
TSCA Under making application to TSCA.

### ■ ISOBAM-304,306

ISOBAM-304 and 306 are Imide types of ISOBAM. These are imide degenerated products based on Standard type ISOBAM

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